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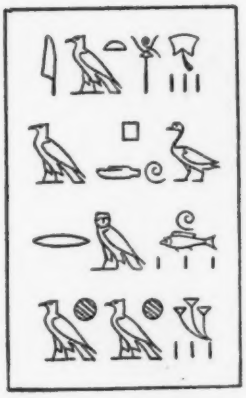

OCTOBER · 1946

Vol. 10 No. 4

CONTENTS

GAME REFUGES AND PUBLIC HUNTING GROUNDS IN MICHIGAN ..... *R. D. Burroughs* 285

FALSE PRINCIPLES DELAY ADVANCEMENT IN WILDLIFE TECHNIQUES ..... *Verne E. Davison* 296

QUANTITIES OF WEED SEED PRODUCED IN CONNECTICUT CORNFIELDS ..... *James S. Bishop and George P. Spinner* 300

USE OF MOWING IN MANAGEMENT OF WHITE LADYSLIPPER .... *J. T. Curtis* 303

USE OF DERRIS TO RECLAIM PONDS FOR GAME FISH ..... *Hilbert R. Siegler and H. W. Pillsbury* 308

EFFECTIVENESS OF A WHITEFISH HATCHERY ..... *Richard B. Miller* 316

FOOD HABITS OF WILD GEESE ON THE GULF COAST OF TEXAS ..... *W. C. Glazener* 322

THE MERRIAM TURKEY ON THE SAN CARLOS INDIAN RESERVATION ..... *Adolph Murie* 329

TRAPPING WILD TURKEYS ON THE KENTUCKY WOODLANDS REFUGE ..... *Walter R. Sylvester and Preston W. Lane* 333

ELECTRIC INCUBATOR FOR GAMEBIRD EGGS (Pl. 21) ..... *R. E. Yeatter* 342

BEAVER MANAGEMENT IN THE NORTHERN BLACK HILLS OF SOUTH DAKOTA (Pl. 22) ..... *Dave Harris and Shaler E. Aldous* 348

COLORED RODENT BAITS AND THEIR VALUE IN SAFEGUARDING BIRDS ..... *E. R. Kalmbach and J. F. Welch* 353

NEWS NOTES 360

CONSTITUTION AND BY-LAWS OF THE WILDLIFE SOCIETY 361

BRIEFER ARTICLES

IMPROVED METHOD FOR ESTIMATING NUMBERS OF WATERFOWL (Pls. 23, 24) ..... *George P. Spinner* 365

CONSERVATION OF MEGAPODS BY SOLOMON ISLAND NATIVES ..... *A. J. Nicholson* 366

USE OF OAKS BY BEAVERS IN NEW HAMPSHIRE ..... *William J. Jahoda* 366

ANTELOPE FOODS IN SOUTHEASTERN MONTANA ..... *Faye M. Couey* 367

REVIEWS 368

OBITUARY: RALPH M. KRIEBEL 372

INDEX, VOLUME 10 373

TITLE PAGE AND CONTENTS ..... i–iv

OFFICERS, COMMITTEES, AND MEMBERS, THE WILDLIFE SOCIETY, 1946 ... v–xxvii

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GAME REFUGES AND PUBLIC HUNTING GROUNDS IN MICHIGAN

R. D. Burroughs

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Since 1938 when Federal Aid in Wildlife Restoration funds were made available to acquire land for wildlife restoration, many states have obtained large acreages for the protection and management of game species. If these areas can be developed and managed so as to restore the ecological balance for the species chiefly involved, the Pittman-Robertson money will have been well spent.

Michigan entered the game refuge business about 30 years ago when it was generally believed that closing an area to all hunting would work wonders in increasing game populations, particularly if predatory species were kept in check. This belief is still widespread among sportsmen, and it is difficult to convince them that factors other than over-hunting and predation may be more important in limiting animal populations.

The following account of experience in the acquisition and management of refuges and public hunting grounds in Michigan may be helpful to game technicians and conservation officials faced with similar problems.

NORTHERN WILD-LAND REFUGES AND PUBLIC HUNTING GROUNDS

In Michigan, the first state-owned game refuge was established in 1916, when Erasmus Hanson deeded 13,826 acres of cut-over land in Crawford County to the State with the provision that it remain perpetually a state forest, game refuge, and military reservation. There is evidence that this tract had functioned as a private wildlife sanctuary for a few years prior to 1916, and that the legislature had authorized acceptance of the land and set aside funds for its management and development as early as 1913 (Act 172, P.A. 1913). A second unit, the Midland Refuge, comprising 2,296 acres of poorly drained cut-over land in Midland County, was acquired in 1922.

By 1924 eight state-owned refuges totalling 47,396 acres had been established; the Second Biennial Report of the Department of Conservation (1923–24) describes these as follows:

"Eight of the largest state reserves are under the supervision of resident keepers whose prime duties are protection of the area from forest fires, de-

struction of vermin and the propagation of game birds and animals. Each . . . is fenced in its entirety and posted with proclaiming notices regularly spaced along its border. Fire lines, reestablished annually, carry a width of from twenty to thirty feet, meandering the entire area. Increase of game, particularly ruffed grouse, has more than met expectations and the areas are proving fine distributing points for restocking of adjacent covert."

The state reserves then were as follows:

Midland Game Reserve, Jerome township, Midland County, 2,298.12 acres.

Emmet Game Reserve, Bliss township, Emmet County, 3,840.58 acres.

Otsego Game Reserve, Corwith township, Otsego county, 9,600 acres.

Gladwin Game Reserve, Sherman township, Gladwin county, 5,712.90 acres.

Cheboygan Game Reserve, Waverly township, Cheboygan county, 3,436.05 acres.

Black Lake Reserve, Grant and Bearinger townships, Cheboygan county, 4,969.17 acres.

Iosco Game Reserve, Oscoda township, Iosco county, 4,040 acres.

Hanson Game Reserve, Military Reservation, Crawford county, 13,500 acres.

In 1924, the effectiveness of refuges in restocking adjacent coverts was accepted as a cardinal principle in conservation and this idea has persisted in the public mind; but recent knowledge of the habitat requirements and behavior of game species do not permit accepting that viewpoint at face value.

Artificial propagation of pheasants, wild turkeys, and other game birds was tried on some of the early refuges but proved impractical, and by 1926 all such activities had been transferred to the State Game Farm at Mason.

In 1926 the Office of Game Refuge Development was established as a Division of the Conservation Department and given complete responsibility for all refuge personnel, surveys, investigations, and development programs.

As early as 1922, the Conservation Commission passed a resolution to the effect that "as far as practicable, a zone of public hunting ground should surround all State Game Refuges" and, in addition, directed that "all State-owned lands in the counties of Alpena, Montmorency, Oscoda, and Alcona, except such lands as may now be dedicated to game refuge purposes, be hereby set aside as public hunting grounds for the benefit of all the people."

The importance of public hunting grounds in relation to refuges was further emphasized in 1926 when standard specifications for state game preserves were adopted. P. S. Lovejoy, then in charge of the Office of Game Refuge Development, expressed his views on public hunting grounds as follows:

"For a number of years the Department has been experimenting with various forms of State Game Refuges and methods of operation, and is now in a position to recommend and administer a rapidly expanding program which will assure better and steadily improved hunting throughout enormous acreages of our wild lands, and especially in case of deer.

"It is no longer proper, or safe, to depend upon the unasked permission of private land owners for hunting privileges in wild land districts and only direct public control of the necessary acreage can prevent a rapid decrease in the choice hunting grounds which are open to the general public" (Lovejoy, Mich. Dept. Cons. Bien. Rept., 3, 1926).

In 1928 the office of Game Refuge

Fig. 1. Game refuges and public hunting grounds in Michigan, past and present (indicated by numbers). See Tables 1 to 4 for details.

Development was abolished and the Game Division of the Department was organized, with P. S. Lovejoy in charge. All of the diverse game and fur activities of the Department except law enforcement were thus brought under one head. A technical staff was assembled including two foresters with considerable experience in wild-land surveying and cover-mapping; a specialist to supervise licensed fur-farms; a specialist to study waterfowl management; and an economic mammalogist for technical problems involving deer, bear, elk,

wolves, coyotes, foxes and other important mammals.

A Refuge Inspector was also appointed to provide closer supervision of the resident refuge keepers and of the improvement work on refuges. After detailed surveys had been made, some units which were not functioning as "standard" refuges surrounded by public hunting grounds were transferred to other agencies for administration. The Emmet Refuge was transferred to the State Parks Division and became the Emmet Wilderness Park and Wildlife Sanctuary; the Black Lake Refuge was transferred to the Forestry Division; the Superior Refuge, dedicated to a reindeer stocking experiment, was also turned over to the Forestry Division as the reindeer failed to survive; the Custer Refuge (military reservation) was abandoned as impractical; and the Midland Refuge was temporarily turned over to the Bay City, Saginaw, and Midland chapters of the Isaac Walton League for administration.

By December 1928, only eight refuges remained, totalling 38,804 acres. An additional 8,040 acres of private land within the refuge boundaries had been brought under administration by lease and 7,552 acres in the Huron National Forest was closed to hunting and trapping by special arrangement with the U. S. Forest Service.

The state-owned public hunting grounds encompassing the refuges totalled 30,400 acres. Large areas for public hunting were available surrounding the Ogemaw, Iosco and Tawas refuges, and small areas near the Crawford (Hanson), Montmorency, and Otsego refuges; but none had been acquired in the vicinity of the Gladwin and Midland refuges (Table 1).

In 1931 considerable impetus was given to the northern wild-land refuge problem when the legislature authorized ear-marking $1.50 from each big game license fee "for the exclusive purpose of acquisition, protection, development, and maintenance of refuges

TABLE 1.—STATE GAME REFUGES IN MICHIGAN (1928).

Number on Fig. 1	Name of area	Year established	Total acres	State land in refuge, acres	Leased land in refuge, acres	Public hunting grounds around refuge, acres
1	Crawford[a]	1916	21,165	15,195	—	1,880
2	Gladwin	1922	4,793	4,153	—	—
3	Iosco	1926	6,700	3,960	1,040	3,880
4	Midland	1920	2,536	2,296	—	—
5	Montmorency	1926	4,800	4,560	40	4,120
6	Ogemaw	1926	5,680	3,320	160	5,560
7	Otsego	1924	12,160	5,320	6,800	6,000
8	Tawas	1926	7,552[b]	—	—	8,960
	Totals		65,386	38,804	8,040	30,400

[a] Originally dedicated as Hanson Reserve.
[b] Huron National Forest land dedicated as refuge by special arrangement with U. S. Forest Service.

and public hunting grounds" (Act 286 P. A. 1929; Am. 1931, Act 325). A period of expansion followed; new units were dedicated; and thousands of acres were acquired by purchase, tax reversion, and exchange.

By 1934, four new units had been dedicated. The total state land closed to all hunting within these "standard" refuges was then 86,244 acres and the public hunting grounds surrounding the refuges aggregated 137,547 acres (Table 2).

TABLE 2.—STATE GAME REFUGES IN MICHIGAN (1934).

Number on Fig. 1	Name of area	Year established	Total acres	State land in refuge, acres	Leased land in refuge, acres	Public hunting grounds around refuge, acres
9	Alpena	1932	1,800	1,765	—	5,715
1	Crawford (Hanson)	1916	18,128	15,382	—	12,280
10	Cusino	1932	5,230	5,030	—	14,854
11	Escanaba River Tract[a]	1930	69,120	—	—	54,180
2	Gladwin	1922	4,793	4,097	—	4,120
3	Iosco	1926	6,800	4,920	1,040	8,790
5	Lunden (Montmorency)	1926	4,800	4,800	—	14,640
4	Midland	1920	2,560	2,320	—	5,280
12	Molasses River	1933	30,080	24,760	—	18,080
6	Ogemaw	1926	6,460	5,300	—	14,328
7	Otsego	1924	8,630	7,990	—	19,620
13	Pigeon River	1929	11,520	9,880	—	19,840
8	Tawas	1926	6,040[b]	—	—	—
	Totals		175,961	86,244	1,040	191,727

[a] No refuge in area.
[b] Huron National Forest land administered as refuge.

An additional 54,180 acres (Escanaba River Tract) in Dickinson and Marquette counties was purchased between 1930 and 1934. The original plan called for a refuge with a large public hunting ground, but the refuge had not been dedicated by 1934. The plan was abandoned when it became evident that the area already supported a deer herd about equal to the carrying capacity of the winter range.

By 1938, there were 20 areas under administration, but only 11 included refuges, and only 78,996 acres were closed to hunting and trapping. The balance of the 493,105 acres acquired by the Department in these areas by purchase, tax reversion, and exchange was administered as public hunting grounds.

Since 1938 the state-owned public hunting land has more than doubled. The areas under administration number 24, and the state-owned land totals 1,189,064 acres. During 1939–44, there were 183,423 acres purchased with money from the $1.50 deer license fund and 512,536 acres acquired by tax reversion and exchange. Meanwhile, the

refuge land in public hunting grounds of northern Michigan was reduced from 78,996 to 37,098 acres (Table 3). In the spring of 1942, as a result of this shift in emphasis, the Conservation Commission officially designated as

lett, 1938). Certain factors that had tended to reduce the herd then were partially eliminated or corrected. The forest fires which had wiped out vast areas of potential deer range were gradually being brought under control, the

TABLE 3.—STATE GAME AREAS IN MICHIGAN (1944).

Number on Fig. 1	Name of area	Year established	Total acres	State land in refuge, acres	State land open to public hunting, acres
14	Arenac	1937	22,144	—	10,160
15	Au Gres River	1942	13,327	—	7,146
16	Cedar River	1940	144,666	—	63,720
10	Cusino	1932	512,766	—	235,228
17	Dead Stream	1937	70,244	—	52,160
11	Escanaba River	1930	722,076	—	405,436
18	Flynn Valley	1942	822	—	742
19	Garden	1944	35,265	—	20,539
2	Gladwin	1922	10,317	4,793[a]	3,307
1	Hanson	1916	18,129	16,298[b]	—
20	Houghton	1942	40,247	—	19,163
3	Iosco	1926	31,690	—	21,728
21	Iron	1942	161,760	—	53,158
5	Lundeen	1926	53,367	—	31,491
22	Luther-Baldwin	1935	94,833	—	31,354
23	Menominee	1942	36,683	—	22,480
4	Midland	1920	49,116	2,377[a]	22,529
24	Munuscong[c]	1925	75,178	520	47,529
25	Norway	1937	96,594	—	59,634
6	Ogemaw	1926	6,432	2,000[b]	3,994
26	Ontonogan	1942	28,332	—	12,136
28	Osceola	1942	26,960	—	14,407
27	Sage River	1937	20,122	—	18,280
29	Wolf Creek	1935	15,258	—	5,158
	Totals		2,286,328	25,988	1,161,479

[a] Closed to hunting and trapping except during open deer season.
[b] Closed to all hunting and trapping.
[c] Waterfowl refuge and public hunting ground; area administered as state park, 1925–43.

State Game Areas all lands formerly classed as refuges and public hunting grounds.

REFUGES AND DEER POPULATIONS

We do not know how much influence the early refuges had in restoring the deer herd. In 1915 the deer were at a low level and hunting in the Lower Peninsula was poor until 1920 (Bart-

buck law was enacted, and law enforcement improved.

The increase in deer population was slow at first, but after 1925 became noticeable, and by 1930 the herd exceeded the carrying capacity of the range in certain areas. This was particularly evident in the refuges and in the "club" areas where hunting pressure was light (Bartlett, 1938).

As a result, by 1940 the Commission had opened most refuge areas to public hunting. The Tawas Refuge (6,040 acres) within the Huron National Forest in Iosco County was discontinued in 1936. The closing order on the Iosco Refuge, comprising 6,880 acres was rescinded in 1938.

Of the Ogemaw Refuge, all but 2,000 acres was opened to hunting in 1939; the closed area serves to protect a semi-tame deer herd which annually attracts several thousand visitors to the Ogemaw headquarters.

The Gladwin Refuge was opened in 1938, but only for deer and bear hunting. For several years the Saginaw Field and Stream Club had held grouse field trials within the refuge, and had spent time and money in laying out field trial courses. Similar improvements were made by the Department of Conservation in 1944 for the national grouse field trials in November of that year. The area probably will remain closed to small game hunting so long as there is need for a public field trial course.

The Lunden Refuge was reduced from 4,800 to 2,500 acres in 1938, and in 1939 opened entirely to public hunting.

The Molasses River Refuge, established in 1933 within the Ogemaw State Forest, was reduced from 30,080 to 10,923 acres in 1936 and to 4,560 acres in 1938. In 1939 the closing order was allowed to expire. The Alpena Refuge (1,754 acres) within the Alpena State Forest was opened to hunting in 1939. The Cusino Refuge, of 5,220 acres, also was opened to hunting in 1939 after being closed for seven years.

The Pigeon River Refuge was opened in 1939, but the neighboring Otsego Refuge remained closed for another year pending investigation of an elk herd ranging nearby. After it was learned that the elk spent most of their time on private land, the Otsego area was opened to hunting.

The Midland Refuge was opened to deer and bear hunting in 1939, but being used extensively for field trials is open only during the deer season.

As of December 1945, two of the 24 northern state game areas are functioning as inviolate sanctuaries; two are combination refuges and public hunting grounds; and one is a combination public hunting area and waterfowl refuge.

It is evident from the foregoing that the Michigan policy for northern wildland refuges has remained flexible. Inviolate sanctuaries may have been important in early phases of conservation, but under current conditons are believed to be of little value in big game management. Present-day knowledge of population dynamics, and experience in management of game range, clearly indicate that refuges should be manipulated to balance game populations with carrying capacity. Gabrielson (1943) emphasized this in stating that "the chief concern of every big game refuge manager is to keep his herd in balance with the available food supply."

The rise and decline of big game refuges in Michigan indicates that the shift in emphasis from "refuge" to "public hunting ground" followed the build-up of the deer herd to a stage where "over-browsing" of the winter range became of major concern.

Herd control by the legalized shoot-

ing of antlerless deer in over-browsed areas would be the most direct approach to this problem, but there is a widespread feeling among Michigan hunters that shooting antlerless deer would "wipe-out the herd." Until such time as public opinion changes with respect to the "buck law," it seems improbable that the legislature will amend the game statutes to permit control by this method.

STUDIES ON HABITAT MANAGEMENT

As an approach to the problem of over-browsing, habitat management has been investigated by the Department for almost 20 years. The study of winter deer yards was begun in 1928 (Bartlett and Stephenson, 1928), and by 1938, 238 deer yards of 1,400 square miles in the Upper Peninsula and 236 deer yards of about 500 square miles in the Lower Peninsula had been surveyed. Analysis in 1941 indicated that 12 per cent of the yarding area in the Upper Peninsula and 45.7 per cent in the Lower Peninsula were in good condition; 39.8 and 23.5 per cent, respectively, were in fair condition; whereas 47.5 per cent in the Upper Peninsula and 30.8 per cent in the Lower Peninsula were in poor condition.

Early in 1943 the Department resurveyed the more important deer-yards, and 63,424 acres of state-owned land in 112 yards were dedicated for game management.

Experiments were initiated at the Cusino State Game Area in 1936 to determine the nutritional value of various browse plants, and the amount of acceptable and available browse per acre in different types of winter deer yards in northern Michigan. A study of the sustained carrying capacity per acre of yard was also undertaken (Davenport, Shapton, and Gower, 1944). This work demonstrated that our preconceived ideas of deer yard carrying capacity were low, but that when deer-yards were over-populated the loss in carrying capacity (deer-days of browsing) was disproportionately large.

Experimental release-cutting projects have been conducted since 1934 in an effort to develop specifications for improving yarding areas. Many types of cutting and slash disposal have been tried on selected sites involving varying cover types to determine which would favor the seeding and growth of cedar and other preferred browse plants. The results are inconclusive, but it appears that better results are obtained, particularly in coniferous swamps, if a moderate canopy is preserved. Grasses and other competitive species, together with browsing, tend to inhibit the immediate reestablishment of coniferous species in clear-cut swamps. The fresh slash from logging, in both coniferous swamps and hardwood stands, during recent winters, has been important in reducing deer losses from starvation in many over-browsed areas.

The history and effect of forest fires on the ecological successions of northern forest types was the subject of a Pittman-Robertson research project during a three-year period ending January 31, 1943. The effect of forest fires on game populations was also traced, and the practicability of using fire as a tool in game management under Michigan conditions was considered (Jenkins, 1942).

The state game areas and dedicated deer yards under the Game Division

provide unlimited opportunity for continued research in every phase of game habitat management. Experimental projects can continue for long periods without the loss or impairment of results due to changes in policy or shifts in land ownership which have virtually ruined several promising research projects before completion.

ACQUISITION OF PUBLIC GAME AREAS

Prior to 1938, when Pittman-Robertson funds became available, but little consideration had been given to providing public game areas in southern Michigan.

Soon thereafter the basic policies were approved and surveys were initiated to locate favorable blocks of submarginal, abandoned, or unused land in the southern counties which could be purchased at reasonable cost—land that could be dedicated to wildlife restoration without interfering with the agricultural interest of the state.

The soils in most of these counties had already been classified and mapped by Michigan State College. A good start also had been made by state and federal agencies in rural land planning. These sources proved valuable in locating the kinds of land that could be purchased and developed. Nevertheless, a soils specialist was employed to examine the land under consideration, and to prepare soils maps as a basis for drawing ultimate boundaries of projects. Cover maps were also made for each area, and these have proved invaluable in planning for development and management of the game range.

The selection of project areas, however, was not determined entirely by soil types. Other factors such as topography, drainage, and surface water were taken into account. Location with respect to the larger towns and cities was also given considerable weight in determining priorities.

By June 1945, the Department had acquired, by purchase and tax reversion, 54,481 acres in 15 Pittman-Robertson project areas, and 9,936 acres in four independent units (Table 4).

MANAGEMENT AND DEVELOPMENT

Management problems in the northern wild land areas were discussed earlier. In certain respects, the development and management problems in the southern areas are more difficult. Land marginal or submarginal for agriculture is likewise submarginal for farm game such as cottontails and pheasants. To maintain satisfactory populations of these species, a careful program of food and cover management is necessary. Because of the war, little progress was made, and improvement work initiated previously was discontinued.

Cover management has consisted of planting some abandoned farm fields with various trees and shrubs to provide escape coverts and a wider choice of food items for game birds and mammals. The planting pattern has consisted of irregular clumps and travel lanes arranged to insure a maximum of forest edge. Generally only 10 to 15 per cent of the open land in any field was reforested. About 792,000 trees and shrubs had been planted by July 1942, when the work ended. Only 879 acres were actually planted, but about 8,000 acres of open land were serviced.

Limited farming was continued on four southern game areas by a system of

sharecrop tenancy. Most of the state's share was left on the land as a source of winter food for wildlife.

Food patches have not been used extensively in our management program, but this type of food management may be expanded to test its practicability from the standpoint of cost and yield on the one hand and from its value for wildlife on the other.

TABLE 4.—LAND ACQUISITION IN SOUTHERN STATE GAME AREAS OF MICHIGAN. (to June 30, 1945)

Number on Fig. 1	Project	County	Purchased, optioned, acres	Tax reverted, acres	Total state-owned land, acres
30	Barry	Barry	10,693.95	349.00	11,042.95
33	Dansville	Ingham	2,221.89	—	2,221.89
40	Deford	Tuscola	3,533.39	120.00	3,653.39
48	Flat River	Ionia & Montcalm	3,930.76	132.39	4,063.15
31	Gourdneck	Kalamazoo	1,226.26	26.48	1,252.74
37	Gratiot-Saginaw	Gratiot & Saginaw	5,055.45	4,219.65	9,275.10
34	Gregory	Livingston	681.66	—	681.66
45	Lapeer	Lapeer	2,073.89	—	2,073.89
42	Minden City	Sanilac	2,355.61	2,705.19	5,060.80
35	Oak Grove	Livingston	664.50	419.00	1,083.50
43	Port Huron	St. Clair	4,289.41	—	4,289.14
36	Rose Lake Wildlife Experiment Station	Clinton & Shiawassee	1,682.33	—	1,682.33
39	Tuscola	Tuscola	3,017.43	1,212.37	4,229.80
38	Vassar	Tuscola	1,262.69	—	1,262.69
46	Pointe Mouillee	Monroe & Wayne	2,608.04	—	2,608.04
	Subtotals (Pittman-Robertson)		45,296.99	9,184.08	54,481.07
44	St. Clair Flats	St. Clair	692.22	7,175.50	7,867.72
32	Fulton	Kalamazoo	652.00	—	652.00
41	Saginaw Bay	Tuscola & Bay	1,715.42[a]	—	1,175.42
47	Erie		240.63	—	240.63
	Subtotals (Other projects)		2,760.27	7,175.50	9,935.77
	Totals		48,057.26	16,359.58	64,416.84

[a] Provides 54,104.84 feet of frontage on Saginaw Bay.

DISCUSSION AND CONCLUSIONS

This history of refuges and public hunting grounds in Michigan probably resembles that in other Great Lakes states. The policies and program had to be adapted to the changing conditions on vast areas of game range. In the earlier phases, the major objective was to save the vanishing wildlife. There is pretty clear evidence now that cycles in wildlife populations are synchronized with other closely related biological cycles, and also with more distantly related cycles involving human economics and sociology. The deer came back after it had been demonstrated that much of the cut-over and burned-over land in the north was too poor to support profitable agriculture.

The need for forest products provided impetus for fire control, and nature did the rest. Protection through refuges, restricted hunting, and game law enforcement were not without influence, but they probably played a minor role.

Experience with small game in both northern and southern sections of the state suggests something of the same pattern. High populations of pheasants occur on the best farm lands in southern Michigan, but have remained very low on sections there characterized by poor soils and rugged topography.

Studies at the Rose Lake Wildlife Experiment Station and at the Prairie Farm have demonstrated clearly that pheasants and other farm-game species can withstand almost unlimited hunting pressure provided natural escape coverts are plentiful and well distributed in the habitat, and further provided that in case of pheasants only cocks are legal game (Burroughs and Dayton, 1941; Shick, 1944).

The state game areas in southern Michigan generally support a good pattern of natural escape coverts and, despite heavy hunting pressure, few refuge areas seem necessary under present conditions.

In projects where waterfowl are important, however, provisions have been made for refuge units and the future policy and program of the Department for those species will depend upon experience in the management of marsh habitats during the next few years.

SUMMARY

The first state-owned big game refuge in Michigan was established in 1916; by 1924 eight refuges totalling 47,396 acres had been established; by 1934 twelve "standard" refuges were in operation which involved 86,244 acres of land closed to hunting and 137,547 acres of surrounding public hunting grounds; by 1938 one refuge unit had been dropped reducing the area of "closed" land to 78,996 acres, but the area of public hunting grounds had increased to 493,105 acres. By 1944 the state had acquired 1,189,064 acres of northern wild land in 24 administered units, but the area of "refuge" land had been reduced to 37,098 acres.

A shift in emphasis from refuges to public hunting grounds followed the increase of the deer population to where over-browsing became of major concern in many winter yarding areas.

The Department of Conservation expended considerable effort on deer yard surveys and range management studies. Research projects dealt with the nutritional value of various browse plants; amount of available browse per acre in different types of winter deer yards; carrying capacity of deer yards; influence of forest fires on deer range; and practicability of controlled burning for range management.

Since 1938, Federal Aid in Wildlife Restoration funds have been utilized to acquire 54,481 acres of submarginal land on 15 projects in the southern agricultural region of the state; 9,936 acres were acquired in four southern areas with other funds.

The southern areas are being managed and developed mainly as public hunting grounds, but small refuge units are incorporated wherever deemed essential. Emphasis, however, is being placed on food and cover management rather than on refuges in the management of small game mammals and birds.

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FALSE PRINCIPLES DELAY ADVANCEMENT IN WILDLIFE TECHNIQUES

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The wildlife technicians and game managers of today may rightly question some old principles commonly accepted in game management and wildlife research. There is much evidence to support a statement that false principles delay advancement in such matters. A few examples will illustrate the point.

"*Bobwhites eat good food without hesitation.*" Most people interested in bobwhites believe that quail must "get used" to a new kind of seed before they eat it. This is a false idea, as quail will eat a *good* food without hesitation.

Many conservation leaders have explained the failure of poor foods (newly planted) by saying, "it often takes 3 or 4 years for birds to learn to eat new things." Our experience with sericea lespedeza showed that quail ate it only occasionally during the first 3 or 4 years. After 10 years we also find them eating it only occasionally. At the same time the Soil Conservation Service was concerned with another new quail food —bicolor lespedeza. Unless birds would eat this new seed, the value of the shrub lespedezas would be small.

Late in the summer of 1945 three game preserve managers in Jasper County, South Carolina, proposed to test bicolor. They thought the experiments would require 3 or more years before food studies might reveal the first bicolor seed in the birds' crops.

We knew, however, that quail fed regularly on the seed of bicolor which had been established a few years before.

Milbank Plantation was raising quail in captivity so we tried bicolor seed on the pen-reared birds one afternoon. One bird, 8 or 9 weeks old, was feeding listlessly from a pan of chick feed. Several others rested lazily around the pen. As the manager poured a few dozen seeds into the pan, the lone quail tasted a seed, and almost immediately gave the familiar call to food. The other birds hurried to the feed pan, and in less than a minute all the seeds were eaten. We then offered bicolor seeds to birds only 4 weeks old. Three little birds at the feed-pan did not call, but ate the 25 or 30 seeds as fast as they could pick them up.

Wherever we have planted bicolor in correct field patterns, bobwhites have eaten the seeds readily the first year. We have killed quail on scores of first-year strips of bicolor. A study of the foods in their crops confirmed the evidence given by Mr. Milbank's pen-reared birds.

Certainly bicolor is one of the best of quail foods, whereas sericea is a poor one. The birds like bicolor. Yet we once put out this excellent food-plant in a poor pattern, so widely spaced that grass grew heavily beneath it and hid the seeds from the birds. They did not eat bicolor under those conditions. These experiences do not indicate anything temperamental in the feeding habits of quail. (Cottontail rabbits eat the bark of bicolor the first year it is planted.)

Reluctance or delay in using a food patch may indicate: (1) a poor food, (2) an insufficient amount, (3) a useless pattern, or (4) inadequate cover nearby. Unless someone has definite proof to support the old theory we should abandon it.

"*This thing called edge.*" Out of Leopold's "Game Management" came the adage that "game is a phenomenon of edges." This assertion beclouds the more significant principle that each kind of game requires enough of the essential elements to make a habitable range. Leopold also said, "the crying need of the conservation movement is *specific definitions* of the environment needed by each species."

Edge happens to be a phenomenon of good range only at times, and then only for a few species of wild animals. It has no significance for the more mobile kinds, as noted by Leopold. Consequently what is to be gained by perpetuating the theory of "edge"?

Throughout the country, the field border alongside woodland is an outstanding example of "edge." How does it withstand analysis as an influence for the bobwhite, a classic species supposedly responsive to edge? The commonest border is relatively bare of vegetation, having neither cover nor food. The woods on the one side often contain large trees without shrubs or grasses, sometimes grazed. The fields of cotton, tobacco, or freshly prepared lands for wheat and corn provide no food. The edge is there, but quail are not.

We do find birds *close* to the edge where the woodland contains some shrubs and the field yields food in the form of seeds from legumes, grasses, or weeds. Yet, when the woods contain

abundant food such as acorns or occasionally pine mast, the birds are not at the edge.

In the Southeast we can grow a good roosting cover, sericea lespedeza, on the formerly bare edge and create a border with an environmental condition which is a fair substitute for grass cover. Even this improvement of the edge is not sufficient unless a better food and a shrubby escape cover are nearby.

By establishing a specific food, such as bicolor lespedeza, in a 15-foot strip of the border we find birds phenomenally, without regard for the cropland. Here within the border itself is the appearance that game might be a reaction of edge. But another step disproves it: we have moved the bicolor strip into the woods and taken the birds with it, leaving the edge-effect a ghost phenomenon.

It follows that range for quail can be made satisfactory by scattered interspersion of a good food in small, various-shaped plots in either ungrazed grassland or woodland. The pattern seemingly has nothing to do with edges or proportionate linear measurement. From present indications, 5 or 10 small tracts of bicolor in proportions of 1 or 2 parts to 100 parts of woodland, may be sufficient to sustain high populations of quail on southeastern preserves.

We may also find a satisfactory combination of cover and food which can be grown in hedges between cropland, in the proportion of 3 or 4 parts of hedge to 100 parts of field. The linear edge of such hedge patterns may exceed a reasonable proportion with density of game populations. Yet the acreage of wildlife land having dependable cover and food may be commensurable.

RESEARCH METHODS NEED OVERHAUL

Research to find the value of land management practices designed to produce and care for game is often stymied by non-essential steps which delay, reduce, and confuse the results. An example is the common belief that a census is needed before a test can be applied to measure results in terms of annual increase or decrease of population.

As a factor of error, the before and after census is difficult to surpass. Whether the number of game animals doubles or merely increases by 10 per cent is often a result of weather which in itself contains unmeasurable factors for better and worse. Since this variation is known to be wide, what conclusions should we draw from an annual variation?

More dependable comparison comes from current studies of treated and untreated areas, eliminating the uncertainties of annual flux. The skeptic will point out a host of variables between one area and another. The practical student will overcome these variables by testing the practice on many fields—an alternative denied by time to the before-and-after census.

We who deal with land management problems cannot be concerned with variables so slight as not to be recognized easily. To us, a successful practice must be one which works on farm after farm, despite minor differences in habitat. In other words, we can use a reasonable approximation to the exact.

It is evident that wildlife management techniques are far behind the demand for them. We still flounder among an unshapely heap of the theoretical practices which have not been measured in terms of wildlife on the land. The day is here again when we have enough wildlife technicians to study results of field tests. We really know very little about a management procedure until it is applied on a large number of land tracts.

A practice to be tested can be planned and applied as quickly as a man can make a census. Such plans can be made almost any day in the year. The season to apply those plans to the land is usually at a time when censusing is not appropriate. One person can, therefore, set the stage for practical research on 50 farms in a single year and have them scattered over an entire state, or a problem area of any other size. He will have plenty of opportunity to study results and will have a good portion of 50 helpers from the farms. When a practice is proved to be sound, the technician will have many good demonstrations, an equal number of experienced users, and several enthusiastic cohorts. Compare this with intensive research on only one or two farms.

Conservation officials, hunters, and land managers may well demand more attention to practical aspects of research. Technicians will profit by demmonstrating their wares, thus proving the usefulness of their recommendations on the land and in the water where food and cover are expected to harbor game and fish for the user. In other words, unless many treated areas give materially better results than can be found on untreated areas roughly similar—in spite of the fickleness of the weather in that particular year—the practice is a disappointment at best.

CARRYING CAPACITY OF QUAIL LANDS

It is said that one quail per acre is a maximum carrying capacity. Are we to believe that a covey of bobwhites requires 15 acres of space free of any other quail? Or should we look into the space to determine what essential elements may be scarce?

In fact quail seem to require much more than 15 acres per covey—100 acres is nearer an average. Perhaps we should produce one bobwhite per acre consistently on several acres before we worry about more. Yet, as a principle, we may well question that one-quail-per-acre is the limit. Certainly we should be able to produce enough food and shelter to raise a 6-ounce bird on the same amount of land that grows 100 pounds of beef.

QUANTITIES OF WEED SEED PRODUCED IN CONNECTICUT CORNFIELDS

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This study aimed at obtaining quantative data on the species of weeds and the amount of weed seed in Connecticut cornfields to serve in estimating the food produced and available for ringneck pheasants. The place of ecological types in food production and availability is a necessary part of such an estimate.

The study was made during the autumn of 1941. Samples were taken either just prior to harvest of the corn or, where the weeds were still available, immediately afterward. Twenty fields were sampled, seven in the Eastern Highland, seven in the Central Lowland, and six in the Western Highland. In the Eastern Highland three fields were in the town of Lebanon, three in Clinton, and one in New London. The last four fields are near the coast, those at Lebanon about halfway up the state. In the Central Lowland, two fields in South Windsor are above the center of the state, the five in Wallingford below. The fields in the Western Highland are near the eastern edge, the four in Canton above the center of the state, the two in Bristol at about the center. The largest of the fields sampled contained about eight and one-half acres, the smallest about one-half acre. The average size of the twenty fields was about two and one-fourth acres.

Ten plots of one milacre each, were located mechanically in each field. No. 1 plots were in the center of each of the four sides of the field, from the edge of the plowed land into the corn, usually about two rows. No. 2 plots were based on the No. 1 plots and extended further into the field, usually another two corn rows. Two No. 3 plots were taken together in the center of the field. The number of stems of each weed species on every plot was counted and recorded. Time was not available to collect, clean, and weigh all the seeds on the plots, hence the average weight of seed per stem by species was used, with the number of stems, in obtaining total weights. The average weight of seed per stem was obtained by cleaning and weighing the seed from 100 stems of each species, collected from the plots at random.

In the application of the data to the field as a whole, No. 1 plots were applied to a strip of milacre width down the side of the field on which the plot was located. No. 2 plots were similarly applied to a strip inside the first, and the balance of the field area based on the average of the center plots. Table 3 shows the weight of seed per acre for each field, together with the factors of soil type, previous land use, and cultivation.

Eight species of weeds occurred commonly enough to be considered in the tabulations. These species furnished the bulk of the seed produced, in total and in each field. Table 1 gives the species and the average weight of seed per weed stem. Ragweed and pigweed are

TABLE 1.—MAJOR WEEDS OF CONNECTICUT CORNFIELDS.

Species	Average weight of seeds per stem, grams	Percentage of total weight, average of all fields
Ragweed (*Ambrosia artemisiifolia*)	2.81	*52.6*
Pigweed (*Chenopodium album*)	1.53	*9.4*
Smartweed (*Polygonum pennsylvanicum*)	.91	*10.0*
Barnyard grass (*Echinochloa crus-galli*)	.28	*2.4*
Amaranth (*Amaranthus retroflexus*)	.27	*2.3*
Yellow foxtail (*Setaria glauca*)	.15	*16.6*
Witch grass (*Panicum capillare*)	.09	*2.5*
Crab grass (*Digitaria sanguinalis*)	.07	*4.2*

the two heaviest producers per stem, with witch grass and crab grass the lowest. In number of stems per milacre plot, yellow foxtail is highest with 526 recorded. In average density, in plots on which they were found, yellow foxtail, smartweed, and ragweed are high, with pigweed and amaranth low.

The percentage of the total weight of seed on all the fields, produced by each species is also given in Table 1. Ragweed produced more than half of the total seed weight, while barnyard grass, amaranth, and witch grass each produced less than three per cent. There was wide variation between fields, ragweed furnished as high as 95 per cent and as low as one per cent. A maximum of 20 per cent of the weight of seed for some one field was furnished by each of the three low producers mentioned. Pigweed, smartweed, and yellow foxtail each furnished more than 50 per cent of the seed weight on at least one field.

The field edges, in which plots Nos. 1 and 2 were located, were denser (half again as many stems per plot), more productive (nearly three times the seed weight), and supported more species than plots in the centers of the fields. The effect of conditions adjoining the fields was evident in the No. 1 and No. 2 plots, particularly in the distribution of the weed species. The percentage of the 40 No. 1 plots and the 40 corre-

TABLE 2.—PERCENTAGE OCCURRENCE OF WEEDS IN PLOTS 1 AND 2, BY SPECIES AND EDGE TYPES.[a]

Edge types	Ragweed		Yellow foxtail		Smartweed		Witch grass		Crab grass		Amaranth		Pigweed		Barnyard grass	
Plot number	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Dry open	86	61	67	58	39	25	47	42	39	31	47	36	53	22	31	28
Moist open	100	100	40	80	100	100	80	40	0	20	40	60	0	0	40	60
Dry fence row	78	59	85	82	33	30	37	26	19	15	41	44	37	37	22	15
Moist fence row	100	100	50	100	100	50	100	100	50	50	50	50	0	50	0	0
Dry woods	86	86	86	57	29	14	43	29	57	43	43	43	57	71	0	14
Moist woods	66	66	100	66	100	33	66	66	66	33	0	0	0	0	33	33

[a] Edges classified as follows: 36 dry open; 5 moist open; 27 dry fence row; 2 moist fence row; 7 dry woods; 3 moist woods.

sponding No. 2 plots in which a given weed species occurred is given in Table 2, broken down according to conditions adjoining the fields. Certain preferences are immediately evident such as the aversion of pigweed and the preference of smartweed for moist sites.

Ragweed grows under a wide variety of conditions. It is the one species occurring on more than 50 per cent of the plots; yellow foxtail occurs on 48 per cent.

The percentage occurrence of ragweed decreases as the shade increases but not markedly so since partial shade may increase moisture, which is sought. Shade can be limiting, as shown by the effect of woods edges. Yellow foxtail shows no correlation with shade or moisture. Smartweed shows positive correlation with moisture and full sun, with moisture more important. Witch grass shows no correlation with shade or moisture. Crab grass occurs more frequently in shaded places; however, seed production is heavier on dry sites. Amaranth shows a slight preference for dry sites; it is definitely limited by moisture and shade. Seed production is much heavier on dry sites. Pigweed shows positive correlation with dry sites and slight preference for shade; it produces seed best against woods edges. Barnyard grass shows no correlation with shade or moisture, but seed production is better under moist conditions.

Table 3 gives the calculated weight of seed per acre for each of the fields and various other pertinent data. The number of times the field was cultivated, the last date of cultivation, and

TABLE 3.—CALCULATED WEIGHT OF SEED PER ACRE BY FIELDS, WITH DATA ON PREVIOUS USE, SOILS, AND CULTIVATION.

Field location and number	Seed per acre, pounds	Use during previous season	Soil class	Method of cultivation	Date of last cultivation	Times cultivated
New London 1	358	Corn	Good	Hand	June 1	1
Canton 1	241	Corn	Good	Machine	July 1	2
Clinton 1	230	Corn	Good	Machine	July 1	3
Bristol 1	129	Corn	Fair	None	—	0
Lebanon 2	104	Corn	Fair	Machine	July 1+	2
Clinton 3	98	Corn	Poor	Machine	July 1	3
Clinton 2	96	Fallow	Good	Hand	July 15	3
Lebanon 3	94	Pasture	Good	None	—	0
Canton 2	81	Corn	Good	Hand	July 1	2
South Windsor 2	79	—	Fair	—	—	—
Wallingford 3	72	Clover	Good	Machine	June 20	2
Canton 3	66	Corn	Fair	Machine	July 1	3
Wallingford 5	52	Hay	Fair	Machine	July 15	4
Wallingford 4	50	—	Good	—	—	—
Lebanon 1	44	Oats	Good	Machine	June 15	1
Wallingford 1	38	—	Poor	—	—	—
Canton 4	33	Hay	Poor	—	—	—
Bristol 2	33	—	Poor	—	—	—
South Windsor 1	29	Tobacco	Fair	Machine	June 15	1
Wallingford 2	28	Potatoes	Fair	Machine	July 1	3

Average calculated weight of seed for the 20 fields is 97.8 pounds per acre.

the method used seem to have little bearing on the weight of weed seed produced. The estimated soil class shows the effect of fertility on the weed seed production. The average weight per acre being twice as much on soils classed as "good" as on those classed as "fair." Soils probably account for the fact that fields in the eastern highland average nearly 50 pounds more weed seed than the average of all fields, since five of the nine fields classed as "good" were in that region.

The use made of the field during the season prior to that in which the study was made shows the most consistent correlation with the production of weed seeds. The eight fields that had been in corn in 1940 averaged 163 pounds of weed seed per acre, while the eight in other known uses averaged 56 pounds. Soil classes are the same, four good, three fair, and one poor for each group.

The methods used in the study seem adequate since results appear to be consistent and reasonable. The most important weed was ragweed, with pigweed, smartweed, and yellow foxtail valuable. The other grasses and amaranth add little to the food production.

No. 1 plots on the field edges contain more species of weeds, more stems per plot, and more weight of seed than No. 2 plots. Both Nos. 1 and 2 are more productive than those in the centers of the fields, hence small fields are more productive, on a per acre basis, than large.

Much of the corn grown in Connecticut is harvested for ensilage, yet in most cases weed seeds provide a considerable supply of food in these fields. Disregarding availability, the production of weed seed appears ample to support more seed eaters. The increase in weeds present, where corn follows corn, seems to indicate an abundance of unused seed and supports the conclusion that corn fields commonly produce more seed than is utilized by wildlife.

Land use subsequent to harvest, the cover on and adjacent to the field, and availability of certain weed seeds to pheasants rather than the amount of food produced probably determine the value of cornfields to the birds.

USE OF MOWING IN MANAGEMENT OF WHITE LADYSLIPPER[1]

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The white ladyslipper (*Cypripedium candidum* Muhl.) was formerly an abundant plant on the low prairies of Wisconsin and neighboring states. Originally this now-rare orchid was found from New York to Minnesota and from New Jersey to Nebraska. In the eastern portions of its range, as far west as the prairie-forest border, the species was confined to tamarack bogs, while to the west it was almost entirely in open grassland, usually of the tall-grass

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prairie type. In this respect it resembled another rare relative, the prairie fringed orchid (*Habenaria leucophaea*) which had about the same general range and the same east-west differentiation of habitats, with the line of separation also at the prairie-forest ecotone. At present, the prairie fringed orchid is almost extinct in Wisconsin, and the white ladyslipper is dangerously close to the same condition as a result of widespread drainage of swamplands and the essentially complete utilization of prairie lands for agricultural crops (Fuller, 1933). Fortunately, two of the largest known remaining colonies of the ladyslipper occur on the Arboretum of the University of Wisconsin in Madison (Curtis, 1943). Close observation of these colonies over a period of years revealed that they were not holding their own. Accordingly, certain management techniques were investigated to learn how the colonies could best be preserved. The present paper reports on the effects of controlled mowing on the ladyslipper population.

MATERIALS AND METHODS

The white ladyslipper is a small plant, usually 8 to 14 inches tall, growing in compact clumps of 3 to 60 stems from a much branched underground rhizome. The stems appear above ground in Madison about May 1 and ordinarily are in the peak of bloom on May 30. Seed pods are produced by only a small percentage of the flowers and are ripe in September. The leaves are in prime condition in June and begin to dry and turn brown in July as the plants are overtopped by surrounding vegetation. The most luxuriant plants are found in areas of open grassland, with *Muhlenbergia racemosa* and *Andropogon furcatus* as the most common grass species. Typical associated forbs are *Valeriana edulis, Phlox pilosa, Lobelia kalmii, Oxypolis rigidior, Lythrum alatum, Chelone glabra, Parnassia caroliniana,* and *Gentiana procera.* In recent years, the areas of greatest ladyslipper population have become invaded by several shrubs, notably *Cornus stolonifera, Betula pumila,* and the vigorous hybrid, *Betula sandbergii.* In the immediate vicinity of these shrubs, the clumps of ladyslipper gradually have become smaller and less floriferous.

Experiments were begun in 1937 to study the effect of controlled mowing on the vigor of the ladyslipper. This technique was tried because the general region had formerly been used as a mowing meadow for marsh hay and because the control of shrub growth by fire was not practical with the limited personnel available. Two colonies were used, one with about 5,500 flowering crowns (in 1937) and the other with about 1,500 crowns. Permanent control quadrats were laid out at random in both grass and shrub areas of both colonies. Two treatment areas were located in sections typical with respect to size and density of shrub cover. One area was mowed each year between April 15 and April 25 from 1938 to 1942, and the other in late summer (between August 20 and September 4) from 1937 to 1941. The first mowing date was chosen to be prior to the time of stem emergence and hence have no direct injurious effect on the ladyslipper. The later date was typical of marsh hay meadow agronomic practice in southern Wisconsin, hence would duplicate a customary farm operation.

Such a condition is important in the development of feasible wild flower management techniques, since the farmer or practicing conservationist can seldom be convinced of the desirability of employing expensive, non-routine procedures. Mowing was done by hand with long-bladed pruning shears to duplicate, as nearly as possible, the action of a regular mowing machine.

Sufficient chart quadrats were laid out in each treatment area to include at least 100 ladyslipper crowns for each treatment. The average density for treated and control areas was 56 crowns per square meter in 1937. Observations as to number of crowns and number of flowers, were made on June 1 each year. Records also were taken of the size and number of shrubs in both control and mowed areas.

RESULTS

The results of the observations for the five year period are summarized in Figure 1, where the average number of orchid plants in each treatment and in each control for the several years are expressed as percentages of the numbers originally present. This manner of presentation permits direct comparison between treatments and is considered valid since at least 100 crowns were used for each set in arriving at the 1937 average. The ladyslipper population remained essentially constant in the grass areas, but showed pronounced decline in the areas occupied by shrubs. It is also evident that mowing was an effective method for the increase of populations previously affected adversely by encroaching shrubs. Unfortunately, no information is available concerning the effect of mowing on plants growing in grass areas, since it was not believed that such treatment would be beneficial when the experiment was begun. The absolute density of ladyslippers in the mowed areas (86 crowns per square meter) was greater, however, at the end of the five-year period than in the grass area controls (54 crowns). This might indicate that mowing the non-shrub plants would be desirable. An equally probable explanation is that the ladyslippers were able to invade the bare areas remaining beneath the former leaf canopy of the shrubs while extensive spread of the orchids into areas of dense grass sod would be more difficult, regardless of mowing.

The magnitude of increase following spring mowing was slightly greater than that from late summer mowing, but the difference is of doubtful significance. In any event, this does not appear to be of sufficient importance to justify the use of non-economical spring control mowing as opposed to summer mowing with its possibilities of farm value.

Some indication of the effect of mowing on the competing shrubs is given in Table 1, which shows, for *Betula pumila*, the changes in number of stems per square meter and in area of canopy coverage on both spring-mowed and control areas. The decrease in canopy coverage and the increase in stem numbers for the control area in 1942 probably resulted from severe rabbit-browsing of the shrubs in the winter of 1941–42. A similar relationship between stem number and coverage was exhibited in 1939 following the first mowing of the treated area. An initial pruning stimulated the growth of numerous dormant basal buds, but con-

tinued annual removal of the tops resulted in depletion of stored reserves with resultant decrease in amount of top growth. The total crown area was reduced from 3,700 cm.² per meter the first year to 160 cm.² after five years and probably would have entirely disappeared with two or three more years of mowing.

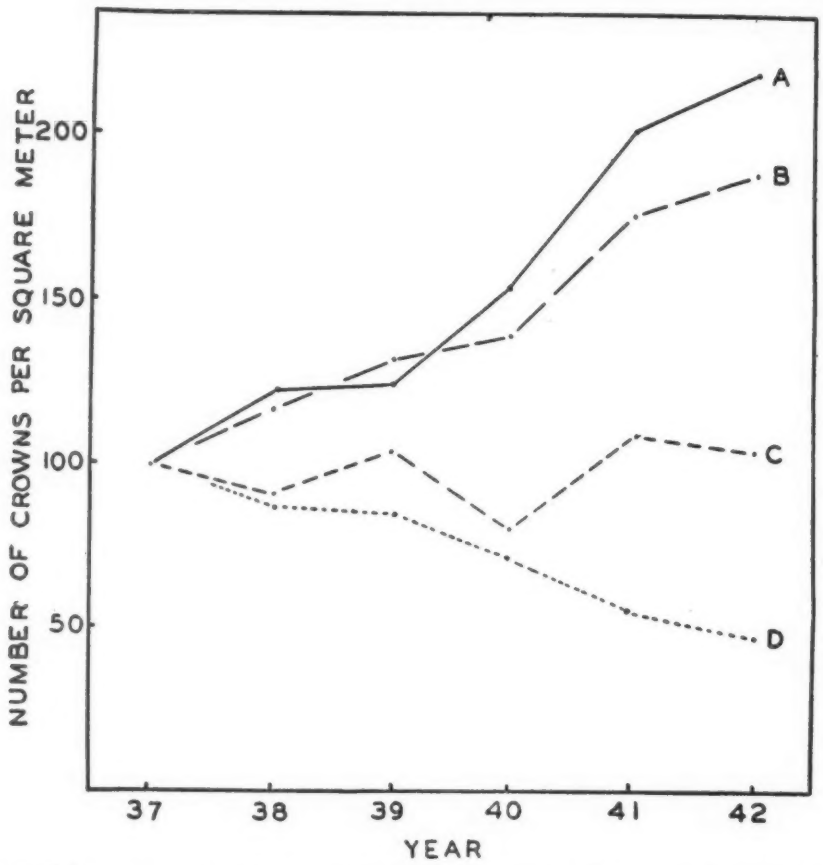

Fig. 1. Effect of annual mowing on the number of crowns of *Cypripedium candidum* per square meter. Values are expressed as a percentage of the average number originally present on each area in 1937. A, shrub area, mowed in April; B, shrub area, mowed in late summer: C, grass area, control; D, shrub area, control.

DISCUSSION

These mowing experiments indicate that artificial control of competing shrubs is essential for maintenance or increase of white ladyslipper populations. A question naturally arises as to the manner by which such populations are perpetuated under natural conditions. Available evidence indicates that the species is shade intolerant and not able to compete successfully under woody plants. In its two natural habitats, the plant was abundant only in open areas. In the bogs it was found

in grass or sedge communities typical of early successional stages or in places where the arborescent tamaracks were sparsely distributed (Morris and Eames, 1929). In the prairie portion of its range, the ladyslipper was most successful in the eastern section where the prairie formation was maintained in opposition to an unfavorable climate because of Indian fires. When such biotic control was stopped, the forest encroached on the prairie and much of the area formerly suitable for this orchid was made untenable.

As a partial counterbalance to the downward trend in total ladyslipper range in the prairie-forest border region, a new biotic control of certain habitats arose which was favorable for the species. This was the development of large-scale mowing meadows for production of marsh hay to be used in the natural ice packing industry. Prior to the widespread introduction of artificial ice and mechanical household refrigerators, the "ice-house" was a prominent feature of most communities in the northern United States located near lakes or rivers. The ice was harvested in winter and commonly packed in marsh hay as an insulating material, particularly when to be shipped by rail to nearby cities. This demand for marsh hay stimulated the use of low prairies or natural marsh areas as mowing fields. In Wisconsin and neighboring states, it also resulted in intentional conversion of many mature tamarack bogs to open sedge or grass meadows. These lands were commonly too wet for agricultural crops without expensive drainage, and the hay was of a quality favorable for packing. Considerable quantities of marsh hay also were used as bedding for farm draft animals.

TABLE 1.—EFFECT OF MOWING ON DENSITY AND CANOPY COVERAGE OF *Betula pumila*.

Year	Ave. no. of stems per sq. meter			Ave. canopy area per sq. meter		
	Control	Mowed	M/C	Control	Mowed	M/C
1938	23	24	105%	3025 cm.²	3700 cm.²	122%
1939	27	33	122%	2925	2266	77%
1940	25	20	80%	3650	1230	33%
1941	33	14	42%	2675	528	19%
1942	40	9	22%	1750	160	9%

The small white ladyslipper, together with certain other herbaceous species native to tamarack swamps, were able to survive conversion to grassland when this resulted from tree cutting and subsequent grass mowing. In fact, the artificial habitat thus created was particularly favorable for the orchid and very dense populations were sometimes produced. Nearly all of the large colonies now remaining in Wisconsin (including those of the Arboretum used in the present study) are on areas showing evidence of former occupation by tamaracks.

Thus for many years (*ca.* 1880 to 1920) the ladyslipper was given a new lease on life because of a particular set of economic factors. Following the de-

cline of the natural ice industry and the mechanization of farms, the mowing meadows were drained where possible or allowed to revert to natural conditions, with no control. Successful drainage resulted in destruction of ladyslipper populations both on the areas used directly for field crops and on the partly desiccated marginal lands. Abandonment of the non-drainable areas resulted in gradual invasion by various woody shrubs (as in the Arboretum) as the first stage in succession to a forest formation, since the meadow is a non-perpetuating plant association in this region. In places of the latter type, the ladyslipper can be maintained by artificial control of the succession through mowing.

No adequate estimate of the total area capable of being managed in this way is available, but certainly it represents only a small fraction of the former range of the species. In wildflower management, as in game management, destruction of environment is far the most important factor affecting the present status of rare species. Suitable techniques for manipulation of specific factors of the environment are essential on natural preserves and in other specialized instances, but they can be only of limited value in the prevention of long-term destruction of many of our most interesting species.

SUMMARY

Populations of the white ladyslipper (*Cypripedium candidum* Muhl.) on the University of Wisconsin Arboretum are decreasing because of invasion of their habitat by woody shrubs. Annual mowing to control the shrubs proved a practical method of increasing the ladyslipper populations.

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USE OF DERRIS TO RECLAIM PONDS FOR GAME FISH

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Fish and game managers find it desirable on occasion to eradicate the animal life of a lake or stream, and rotenone has proved useful for the purpose. Literature describing the method of using this drug in fish management is scattered and meager, and other workers may benefit from experiences with it in New Hampshire where 20 lakes have been poisoned and reclaimed for trout since 1938.

HISTORY AND EXPERIMENTS

Rotenone is found chiefly in derris (*Derris elliptica* and *Lonchacarpus nicou*) and there are many references to its

various uses as a poison; Roark (1932) gives over 450 references on derris. Since 1932 the use of derris has expanded rapidly, with corresponding increase of publications on this material. Most of the articles deal with derris as an insecticide, but some references to fish poison are made.

The rapidly expanding use of derris led to considerable research on the effect of this poison on man. In general limited quantities of derris are not fatal to humans. Haeg (1931) took 2.3 grains and suffered no harmful effects. Previously Buckingham (1930) stated that pure rotenone given to dogs at rates up to one grain per pound of body weight had no apparent ill effects. Our experience with derris leads us to recommend use of a nose and mouth mask while handling the powder, as it is difficult to avoid breathing and swallowing some when mixing with water in open barrels. We suffered no serious after-effects, but experienced uncomfortable constriction of the throat muscles, for several hours afterward. Buckingham worked with warm-blooded animals, and Gersdorff (1930) made a series of tests on the toxicity of rotenone on fish, using goldfish as the test species (Gersdorff, 1930a, 1930b, 1931, and 1937). A comprehensive paper by Leonard (1939) sums up experimental work to that year, including his own findings.

In 1938 the late Earl Hoover pioneered in reclaiming many New Hampshire lakes and streams (Hoover and Morrill, 1938). Other early workers in practical application of this drug to fish management were Eschmeyer (1937, 1938, 1939), McGonigle and Smith (1938), Smith (1940, 1941), and Hagen (1940). Hoover's next operation was of a scope then believed impossible by other workers, the reclamation of 358-acre Back Lake in Pittsburg, N. H. That lake had previously been poisoned with copper sulphate with only moderate success, and by 1938 was overrun with pickerel. In September 1938 the lake was reclaimed by use of derris (0.153 p.p.m.) with complete success. During the next few years 10 other lakes were reclaimed, using various methods for calculation and application. The war interrupted these experiments until August 1945, when derris again became available. This paper reports chiefly on the results with seven ponds since that date.

PRELIMINARY CONSIDERATIONS

The following factors should be considered when poisoning operations are contemplated: accessibility of water to be reclaimed, water sources, outlet, water temperature (or time of year), depth and volume of water, rotenone content of derris, and research possibilities.

It is important to determine the accessibility of the water to be reclaimed, since considerable equipment and derris powder must be transported. For large lakes the total weight often will be several thousand pounds.

The degree of success depends largely on how thoroughly inlet waters are poisoned. If all waters at, around, and above the lake cannot be reached with poison, there can be no guarantee of a complete kill. Large marshes and swamps are difficult to spray thoroughly; unless they can be completely drained, fry or small species of fish will

survive. This is the largest single cause of failure.

Work at the lake outlet, preparatory to poisoning, will generally entail the most labor and the greatest cost. Due to the present limited knowledge, we believe no water should be poisoned that cannot be held for a minimum of three weeks before overflowing. According to laboratory tests by Leonard (1939), the toxicity of commercial powdered derris root at 1.0 p.p.m. (with warranted rotenone content of 5 per cent) dropped below the lethal point for common sunfish and bluegills in 20 to 41 hours after preparation. Brown and Ball (1942) in field tests found the toxicity in unfavorably cold water lasted seven days. In our field operations there was wide variation in the time that the toxic effect of rotenone was maintained in different lakes.

Seven ponds were reclaimed within 40 days (Table 1). Two were ready to be stocked with brook trout 35 days after being poisoned, and two others after 43 days. On the fifty-fourth day after poisoning a fifth lake (Carr Pond), brook trout died within 50 minutes after being introduced, although the concentration of rotenone used was slightly less than in the first four lakes. Two other ponds were poisoned on October 1 and 17. They remained toxic throughout the winter and would not support fish life until the spring turnover. In both cases water from these lakes flowed over the spillways about four weeks after poisoning operations, without any noticeable ill effect on fish in the streams which received this toxic water.

TABLE 1.—EFFECTS OF DERRIS POISONING IN NEW HAMPSHIRE PONDS.

Pond	Date poisoned (1945)	Concentration, p.p.m.	Days water remained toxic to brook trout
Harris	Sept. 6	1.96	Less than 43
Middle	Sept. 12	2.18	Less than 35
Moose	Sept. 12	1.98	Less than 35
Big Brook Bog	Sept. 13	1.95	Less than 61[a]
Carr	Sept. 17	1.85	More than 54
Newell	Oct. 1	0.576	More than 137
Center	Oct. 17	0.465	More than 129

[a] Inaccessability precluded earlier checking.

It becomes apparent that the water temperature or the time of year are important in poisoning operations. Leonard (1938), Greenbank (1940), Smith (1940), and Brown and Ball (1942) have all emphasized the fact that the toxicity of rotenone increases rapidly as the water temperature rises. Experiments by Leonard (1938) demonstrated that an increase in water temperature from 60° to 74° F. almost halved the time in which fish were killed. Brown and Ball (1942) state that rotenone did not affect their experimental fish at 45° F. or lower. The water temperatures when poison was applied to lakes in New Hampshire during 1945 are shown in Table 2. Our experience indicates that at water temperatures down to 48° F., rotenone will kill the fish of a lake ef-

fectively but not rapidly. The colder the water, the longer time needed for the poison to become dissipated. If poisoning operations are carried on late in autumn and cold weather soon begins, the water may remain toxic until the seasonal turnover in spring.

A knowledge of the depth and volume of water are prime requisites. Careful soundings should be made to afford a reasonably accurate calculation of volume. Time being limited we used a faster, less accurate, but effective method to determine the water volume, merely multiplying the surface acreage by the maximum depth. ("Maximum depth" excludes any occasional deep spring hole or ravine on the lake floor.) We thus overestimated the water volume, and increased the cost, more derris being used than necessary. On the other hand the added factor of safety and the greater speed and ease of this method justifies its use in some instances. There is still some question as to the effectiveness of derris in deep water where a thermocline is present. Greenbank (1940) states that derris is much less effective in colder water (Leonard, 1939), and probably does not reach the lower depths in any appreciable amount, as a thermocline may prevent penetration of the poison to the deeper water. Our experience with three lakes did not wholly substantiate this viewpoint, as Round Pond (depth, 55 feet), Center Pond (33 feet), and Newell Pond (28 feet) all were poisoned successfully; each had definite thermoclines.

The rotenone content of the powder must be considered before calculating the poison required. Most reports to date are based on a 5 per cent assay, therefore allowance must be made for lower percentages. Powder ranging from 3.7 to 4.55 per cent rotenone has been used in New Hampshire with complete success.

Finally, since pond reclamation work is comparatively new, no worker should omit the opportunity for much needed research. Some problems much in need of study are: (1) the effect of rotenone on both zoo- and phyto-plankton, and the length of time required for plankton to regenerate in ponds; (2) the effect of rotenone on bottom organisms; (3) the threshold of toxicity for various species of fish, and the use of rotenone

TABLE 2.—DERRIS CONCENTRATIONS USED, WATER TEMPERATURES, AND RATE OF EFFECT ON FISH IN NEW HAMPSHIRE PONDS.

Pond	Concentration,* p.p.m.	Water temperatures, °F		Minutes until first fish surfaced	Time to final kill, hours
		Maximum, surface	Minimum, bottom		
Harris	1.96	74	—	30	2
Middle	2.18	69	62	20	5
Moose	1.98	68	66	15	18
Big Brook Bog	1.95	70	—	30	3
Carr	1.85	58	—	45	
Newell	0.566	64	50	30	20
Center	0.365	63	48	60	26

* Based on water volume as maximum depth × surface acres, not actual volume.

in selective poisoning; (4) a chart showing the rotenone concentration needed to poison fish for every 5°F. change in water temperature; (5) the fertilizing value of dead fish to a lake; (6) the effect of thermal stratification on poisoning operations; (7) the possible use of aircraft for distributing derris over large swamps; (8) an antidote to counteract the effect of rotenone on valuable game fish; and (9) the use of rotenone in streams.

DERRIS REQUIREMENTS

After the concentration of poison to be used has been determined, a formula is used to determine the necessary weight of powder required, as follows:

$$\frac{\text{total acres} \times \text{average depth} \times 43{,}560 \times 62.5}{\text{p.p.m. required (.5 p.p.m. average concentration)}} = \text{pounds needed}$$

For rapid field estimates, surface acres $\times$depth in feet $\times 1.36$ = approximate pounds required. A material saving can be made by using various concentrations, depending on the conditions involved. Table 2 shows the range of poison concentrations used in New Hampshire, the water temperatures, and the time required to kill the fish population.

METHODS OF APPLICATION

Application is possible by several methods, but in New Hampshire practically all have been abandoned in favor of spraying. In our original work, sacks were towed on the surface and others weighted for deep water. In shallow water paper bags filled with a thin batter of derris were thrown out from the shore as far as possible; the moisture-weakened bags would break on impact and release the poison. Men wearing waders and carrying sacks also were used. Bombs made with dynamite in a gallon can of batter were used in Round Pond where there was distinct stratification and deep water. Dynamite is considered essential for a complete kill under floating islands. Large springs need special consideration. Several charges of dynamite or a sack of poison so placed that all water from the spring must pass through, were used successfully in our operations. Spraying was tried first in 1939 with an apple spray rig. On the first attempt, the efficiency with which an even distribution is obtained became evident. Hagen (1940) tried the same method at about the same time and with success. The importance of even distribution over the entire surface as simultaneously as possible cannot be over-stressed. Light weight "Indian" pumps now are used for shoal areas. Two men in a canoe with such pumps can easily reach water that was nearly inaccessible by the older methods of wading along mucky shores or by dragging bags from boats. Spraying also has brought a change in procedure for covering the entire area of a lake. Barrows (1939) describes the former method of strip treatment of the surface by a man assigned to each strip. Where help is plentiful, this method may still be used to advantage, but it can be too expensive. Our method now

is to leave all equipment and poison at one station or two (if the lake is large) and start to apply the poison in a continuous spiral around the pond in a counter-clockwise direction. Since most men work the pump with the right hand, this direction is easier than the reverse. If there is a high wind it is easier to work downwind. One canoe or other boat of slight draft starts within 25 feet or less of the shore, and a second boat immediately behind 25 feet out from the first. The third and other boats do similarly, and maintain their relative positions throughout the operation. The lake is covered completely, much as a large field would be gang plowed. There are no "streaks" of poison as in application with sacks or pouring into the wake of an outboard motor. It is our practice to spray freely all marsh or swamp areas and every inlet. This includes waters that might drain into the pond, even when no water is flowing at the time of reclaiming. A special boat with power sprayer is now being designed. The key to successful poisoning may be an even and rapid distribution of rotenone throughout the water.

TABLE 3.—COST OF DERRIS APPLICATION PER ACRE-FOOT IN RELATION TO CONCENTRATION IN NEW HAMPSHIRE PONDS.

Pond	Acre-feet	Concentration, p.p.m.	Labor, hours	Cost	
				Acre-foot[a]	Totals
Harris	51	1.96	30	$2.59	$132.09
Middle	64	2.18	35	2.73	174.72
Moose	90	1.98	43	2.47	222.30
Big Brook Bog	30[b]	1.95	82	4.75	142.50
Carr	75	1.85	53	2.57	192.75
Newell	225	.576	80	.93	209.25
Center	500	.465	158	.78	390.00
Totals	1,035				$1,463.61

[a] $1.00 per man-hour, but services often donated.
[b] Exclusive of surrounding marsh.

DISPOSITION OF DEAD FISH

The dead fish are somewhat of a problem in reclaiming lakes. Where a study of them is to be made, all the killed specimens can be preserved. Valuable data on growth, weight, and other matters can be learned from study of an entire population. This, however, involves considerable expense which cannot be justified by a fish culturist who must show maximum return for dollars spent. On routine reclamation jobs it is of greater benefit to leave all fish in the water (where public relations do not dictate otherwise) as added fertilization to the pond. Fish that wash on to the shore do not present any problem if the operation has been handled properly. By drawing off a few inches or feet of water, the shore line will be lowered, and dead fish on the shore will decompose; then when the water is raised to the normal level, these fish

will be well below the shore line. A few pounds of fish per acre provide a considerable weight of fertilizer.

COST OF OPERATIONS

Various methods of computing costs for this type of work have been used, cubic feet, gallons, or surface acres being the units often mentioned. We have adopted the acre-foot as the most easily understood unit; it is essentially accurate for all practical work. Figures computed to the nearest acre-foot will give an accuracy down to less than 1.5 pounds of poison required for derris concentrations of 0.5 p.p.m., Table 3 provides a general indication of poisoning costs per acre-foot, not including costs of any large or permanent dams that may have been constructed, permanent equipment, or salary of technicians. Man-hours in normal preparation and in actual poisoning, and the costs of poison and other expenses requisite to all reclaiming operations have been used. The cost of derris is on a sliding scale dependent upon the rotenone content, and a recent price of $0.40 per pound for a 5 per cent assay has been used for these figures.

The cost of $4.75 per acre-foot on Big Brook Bog shows clearly the sharply increased expense for reclaiming swampy or marshy areas. As the percentage of swamp or marsh present increases, the efficiency decreases. The controlling factor is the physical impossibility of covering such areas. When spraying from aircraft becomes feasible, such handicaps may be overcome. At present such areas should be avoided because of the expense and uncertain results. The average cost of operations on the seven lakes reclaimed was $1.41 per acre-foot. Reclamation work is rapidly passing out of the experimental stage, and the attitude of "using twice as much to be safe" should gradually be eliminated. More harm than good may result from over-poisoning; the lowest possible concentrations that will be completely effective should be used. The breaking of a temporary dam, whereby heavily poisoned water escapes, could effectively eradicate entire populations in streams or ponds below. Many workers like to call this over-poisoning their "safety factor." Reasonably accurate calculations will eliminate the added danger and expense.

SUMMARY

Lakes up to several hundred acres in area can be reclaimed satisfactorily for game fish with rotenone. The expense is probably the major limiting factor. For economic reasons the accessability of ponds should be considered in any extensive program.

Unless all head waters and marshy shore areas can be covered entirely there is little probability of a complete kill. Arrangements should be made to hold all water as long as possible; certainly not less than three weeks.

Rotenone will kill the fish population of a lake effectively but not as quickly with water temperatures as low as 48° F.; however, the colder the water, the slower the poison becomes dissipated. Lakes poisoned late in autumn may remain toxic to fish until the seasonal turn-over of water in spring.

Water volume calculations to the nearest acre-foot are accurate enough for all practical purposes in poisoning operations. Calculations based on the weight of derris powder to water weight

must be corrected for rotenone content. A 5 per cent assay has been generally accepted as standard.

Concentrations of 0.153 to 2 p.p.m. of derris powder to water volume have been used with success in New Hampshire, depending on water temperatures and species of fish to be eradicated.

Spraying is the most satisfactory method of application, although this may be supplemented by dynamite under special circumstances. "Indian" pumps have proved very effective in shoal areas.

The fish population should be left in the water as fertilizer wherever possible. The offensiveness of decayed bodies is reduced to a minimum if the water level has been lowered before poisoning.

Cost in New Hampshire is based on the acre-foot unit. The cost of reclamation operations on seven lakes averaged $1.41 per acre-foot and varied from $0.78 to $4.75.

Bog ponds are expensive to reclaim and the percentage killed is necessarily low.

The length of time lakes remain toxic to fish after rotenone is applied varies considerably depending on water temperatures. Of seven ponds poisoned, two could be restocked within 35 days but two others remained toxic to fish all winter.

There are still many problems in lake reclamation work much in need of study; nine of these are listed.

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EFFECTIVENESS OF A WHITEFISH HATCHERY

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During the past twenty years the efficiency of fish hatcheries has been of considerable interest to fishery biologists and administrators. There has been considerable research on the effectiveness of game trout hatcheries, but no attention to whitefish hatcheries aside from some work by Van Oosten (Relationship between the plantings of fry and production of whitefish in Lake Erie. Amer. Fisheries Soc. Trans., 71: 188–121, 1942). Van Oosten found no correlation between fry plantings and subsequent commercial catches of whitefish in Lake Erie. Since several states and provinces spend large sums in operation of whitefish hatcheries, a thorough test of their effectiveness seems desirable.

In cooperation with the Alberta Fisheries Branch, a program to make such a test was begun in 1941. This branch of the government operates a standard 880-jar hatchery (capacity, 140 million eggs) for the propagation of whitefish (*Coregonus clupeaformis*). It was decided to plant "eyed" eggs in a series of lakes on alternate years. Thus Lake A would be planted in 1941 and not in 1942, while Lake B would be planted in 1942 but not in 1941. The plan involved an annual determination of the age composition of the catch from each lake. If the hatchery is effective in increasing the numbers of fish, the year classes should be alternately weak and strong in each lake. For example, if a lake is planted in 1941 but not in 1942 the catch of three year olds should be heavier in 1944 than in 1945; the catch of four year olds should be heavier in 1945 than in 1946, and so on. By using a series of lakes it was hoped that the effect of climatic variations would be minimized. The lakes selected ranged from 12 to 462 square miles in size; any variations in effect of the hatchery in relation to size of lake could thus be recognized.

A considerable series of lakes was included in the experiment but only seven were studied in detail, and one of these is excluded in this report as it was closed to fishing during a part of the experiment. Data for four years have accumulated for four lakes and for five

years on the other two. These records, while not regarded as final proof, indicate that the whitefish hatchery is not producing effective results. Final judgment must be reserved until the experiment has run another five or six years; meantime these data may be useful for any agency considering expansion of its whitefish hatching facilities.

TABLE 1.—PLANTINGS OF WHITEFISH EGGS OR FRY (IN MILLIONS) IN SIX ALBERTA LAKES.

Lake	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944
Buck	—	—	—	—	—	—	—	1	4	—	1
Pigeon	—	—	—	—	4	3	5	—	4	—	4
Ste. Anne	—	—	—	—	5	4	2	—	4	—	2
Lesser Slave	—	—	—	89[a]	61[a]	18	41[b]	30	6	60	—
Cold	—	—	—	—	3	2	5	—	5	—	5
Muriel	—	—	—	5	—	1	1	—	1	—	1

[a] Fry.
[b] Includes 2.5 million fry; remainder were eyed eggs.

TABLE 2.—NUMBER OF WHITEFISH TAKEN AS SAMPLES OF COMMERCIAL CATCH ANNUALLY FROM SIX ALBERTA LAKES.

Lake	Area, square miles	Fishing season beginning in:					Totals
		1941	1942	1943	1944	1945	
Buck	12	—	26	470	87	101	684
Pigeon	40	—	100	331	173	102	706
Ste. Anne	25	—	18	74	170	200	462
Lesser Slave	462	116	99	134	490	500	1339
Cold	140	21	80	48	314	196	659
Muriel	25	—	43	70	66	175	354
Total							4,204

MATERIALS AND METHODS

The record of hatchery plantings in the six lakes, and the sizes of the lakes and numbers of fish studied annually from each are summarized in Tables 1 and 2.

Fish collected in the annual samples were weighed and measured (fork length), and a scale sample from each used to determine age. The percentage thus was established of each age group, and hence of each year class in the catch, assuming that the sample contained the same proportions of fish of each age as the whole commercial catch. The average weights of each age group in each lake then were calculated; using these figures and the total weight of fish taken commercially from the lakes it was possible to calculate the actual numbers of fish of each year class in the commercial catch.

Table 1 will show the use that may be made of these data. The strengths of the year classes of 1936 and 1937 in Lesser Slave Lake may be compared since only the latter received hatchery support; the year classes of 1937 and 1938 offer a variety of comparisons in all the lakes since both received support

in one lake, both received no support in another, and one received support and the other did not in four lakes. The year classes of 1940 and 1941 offer a similar variety of comparisons. Data for Muriel Lake are omitted from these comparisons and used for a special purpose below.

TABLE 3.—TOTAL CATCHES (IN THOUSANDS) OF WHITEFISH OF YEAR CLASSES OF 1936 AND 1937 FROM LESSER SLAVE LAKE, ALBERTA, CANADA.

Year class	Hatchery support	Age at capture, years				Totals
		5	6	7	8	
1936	none	80.5	44.5	3.3	9.3	137.6
1937	89,000,000 fry	33.8	13.5	9.3	3.6	60.2

TABLE 4.—TOTAL CATCHES (IN THOUSANDS) OF WHITEFISH OF YEAR CLASSES OF 1937 AND 1938 FROM FIVE ALBERTA LAKES.

Lake	Year class	Hatchery support	Age at capture, years				Totals
			4	5	6	7	
Buck	1937	none	—	4.6	2.2	2.3	9.1
	1938	none	—	5.4	1.4	2.0	8.8
Pigeon	1937	none	—	29.4	13.1	11.9	54.4
	1938	4,000,000 eyed eggs	—	27.4	31.8	1.8	61.0
Lesser Slave	1937	89,000,000 fry	29.5	33.8	13.5	9.3	86.3
	1938	61,000,000 fry	7.2	25.9	10.9	11.0	55.1
Ste. Anne	1937	none	—	12.5	8.4	3.3	24.2
	1938	5,000,000 eyed eggs	—	8.6	3.6	4.0	16.2
Cold	1937	none	0	3.0	3.1	11.6	17.7
	1938	3,000,000 eyed eggs	0	0	2.3	13.2	15.5

CATCHES OF HATCHERY SUPPORTED AND UNSUPPORTED YEAR CLASSES

Catches of the year classes of 1936 and 1937 from Lesser Slave Lake are compared in Table 3. The data include the catches of both these year classes as 5-, 6-, 7-, and 8-year fish (catches of 1941–45, inclusive). The year class of 1936, which received no hatchery support, yielded commercial fishermen 137,600 fish five to eight years of age, while the year class of 1937, which received hatchery support of 89 million fry, yielded only 60,200 fish of those ages. Despite enormous hatchery support, the year class of 1937 was less than half as strong as that of 1936.

Catches of the year classes of 1937 and 1938 from five lakes are compared in Table 4. The data permit comparisons of the catches of 5-, 6-, and 7-year fish of both year classes from three lakes, and of 4-, 5-, 6-, and 7-year fish from the other two. These two year classes were nearly of the same strength in all the lakes; when the method of calculating the annual catches is considered, the observed differences between year classes probably are not significant. In Pigeon Lake the hatchery supported year class (1938) was slightly

stronger (61,000 fish vs. 54,400); in Lac Ste. Anne and Cold Lake the unsupported year classes were the stronger.

Strengths of the year classes of 1940 and 1941 for five lakes are summarized in Table 5. The data permit comparisons of both year classes as two, three and four year fish. Of particular interest are the figures for Buck and Pigeon lakes; these smaller lakes lie further south and were influenced by early autumn and high winds there in 1941. The year class of 1941 was consequently almost a failure in both lakes. Hatchery support of this year class in Buck Lake failed to improve its strength. In Pigeon Lake the stronger year class of 1940 received the support which, if it accomplished anything, merely emphasized the dominance of an already strong year class. In Lac Ste. Anne and Cold Lake the year class which received hatchery support is weaker than the unsupported year class in both lakes.

In summary, comparison of the strengths of hatchery supported and unsupported year classes reveal no evidence that the hatchery is influencing the numbers of fish. The critical reader will wonder why fishing effort is not taken into account in the calculations; this is omitted for two reasons: a satisfactory measure of effort is difficult to obtain, and the maximum annual catch of fish in all these lakes is set by law (this limit is nearly always taken so that catches per unit of effort have little significance).

TABLE 5.—TOTAL CATCHES (IN THOUSANDS) OF WHITEFISH OF YEAR CLASSES OF 1940 AND 1941 FROM FIVE ALBERTA LAKES.

Lake	Year class	Hatchery support	Age at capture, years			Totals
			2	3	4	
Buck	1940	none	2.3	15.7	7.1	25.1
	1941	1,000,000 eyed eggs	0	0.9	1.8	2.7
Pigeon	1940	5,000,000 eyed eggs	26.0	100.6	52.4	179.0
	1941	none	0	3.2	82.7	85.9
Ste. Anne	1940	2,000,000 eyed eggs	0	0	4.3	4.3
	1941	none	0	2.9	7.7	10.6
Cold	1940	5,000,000 eyed eggs	0	0	0	0
	1941	none	0	0	34.0	34.0
Lesser Slave	1940	4,000,000 eggs and fry	0	5.1	69.3	74.4
	1941	30,000,000 eyed eggs	0	27.9	28.6	56.5

CATCHES OF CERTAIN AGE GROUPS

Some of the data serve to compare the catches of certain age groups taken from supported and unsupported year classes. Thus, in Buck Lake, the catch of three year fish has been calculated for four successive years, two from the year classes of 1939 and 1940 (neither of which received hatchery support), and two from the year classes of 1941 and 1942 (both with hatchery support). The average annual catch of unsupported three year fish was 7,850;

that for the supported is less—880 fish. Table 6 shows the results of such calculations for five lakes, including only those age groups for which at least two samples were available in each category, supported and unsupported.

TABLE 6.—CATCHES OF WHITEFISH OF CERTAIN AGE GROUPS FROM HATCHERY SUPPORTED AND UNSUPPORTED YEAR CLASSES IN ALBERTA LAKES.

Lake	Age group	Number of samples		Average annual catch (numbers of fish)	
		Hatchery support	No hatchery support	Hatchery support	No hatchery support
Buck	3	2	2	880	7,850
Pigeon	6	2	2	20,480	24,225
Ste. Anne	6	2	2	4,110	5,410
Cold	5	3	2	1,230	1,520
Cold	6	2	3	6,390	1,940
Lesser Slave	6	3	2	16,380	44,100
Lesser Slave	7	2	3	10,150	12,950

Seven comparisons are shown in Table 6; in six *the catches of unsupported age groups are larger than the catches of supported age groups.* These data indicate strongly that the hatchery is failing to influence the catch.

EFFICIENCY OF NATURAL SPAWNING

Several attempts were made to collect naturally spawned whitefish eggs from Lake Wabamun. In the first, which garnered 15 eggs, a long hose was lowered through a hole in the ice to the lake bottom, and bottom material pumped up and strained with a fine screen. Later an Ekman dredge was used with better success (Table 7). Of 117 eggs obtained, 15 (12.8%) were fertile and living, two others had died after fertilization, and none of the others appeared to have been fertilized.

TABLE 7.—NATURALLY SPAWNED WHITEFISH EGGS RECOVERED FROM LAKE WABAMUN, ALBERTA, CANADA.

Date	*Eggs obtained*	*Living*
Feb. 13, 1943	15	4
Nov. 17, 1945	50	5
Dec. 29, 1945	26	4
Jan. 26, 1946	26	2
	117	15

On the basis of recoveries of eggs from spawning grounds in Lake Ontario shortly after spawning, Hart placed the efficiency of natural spawning at 65 to 100 per cent, but states that subsequent mortality is quite heavy. In February and March he found only 13 per cent of 15 eggs examined were still living (Hart, J. L. Contr. Canadian Biol. and Fisheries, n.s., 7 (7): 165–214, 1930).

These few eggs offer no basis for positive conclusions, but for the sake of argument, natural efficiency may be inferred at 10 per cent. In a lake the size of Wabamun the spawning population would be at least 150,000 fish. If half were females, about 1.5 billion eggs (20,000 per female) would be produced; and if 10 per cent survived, 150,000,000 fish would be added to the population each year, approximately 100 times the number which the lake can contain as adults.

EFFECTIVENESS OF PLANTING "EYED" EGGS

The tentative conclusions reached here may be criticized on the ground that the Alberta hatchery plants mostly "eyed" eggs rather than fry. But large plants of fry in Lesser Slave Lake in 1937 and 1938 have failed to produce any observable effect; and the eyed eggs do survive and hatch. Several Alberta lakes which had no whitefish populations have received plantings of eyed eggs and now support flourishing fisheries. Of these, Muriel Lake was first planted in 1937 (Table 1), and a complete history of the whitefish in the lake has been made (samples included in Table 2). The first planting yielded good crops of five and six year fish in 1942 and 1943. A further planting in 1939 is now (1946) yielding about 14 per cent of the commercial catch, and another in 1940 is supplying 80 per cent of the commercial catch. There are now year classes in this lake from 1939 to 1944, inclusive, which had the following origins:

Year Class	*Origin*
1944	Hatchery (1,000,000 eyed eggs)
1943	Natural reproduction class of 1939
1942	Hatchery (1,000,000 eyed eggs)
1941	Natural reproduction class of 1937
1940	Hatchery (1,000,000 eyed eggs)
1939	Hatchery (1,000,000 eyed eggs)

This record proves that the planting of eyed eggs is efficient hatchery practice—the eggs hatch and grow into fish. Incidentally, it is of interest that six per cent of the 1945–46 catch was of the year class of 1941, naturally spawned.

DISCUSSION

The evidence here presented is preliminary but suggests rather strongly that the whitefish hatchery in Alberta is having no effect on the commercial catch. Indeed, comparing the yields of hatchery supported and unsupported year classes more often reveals that the supported year classes are actually weaker. It would be absurd to suggest that the hatchery is having an adverse effect, but it seems safe to state that it is having *no* effect.

Why is this so? It is not intended to argue that hatchery introduced eggs or fry do not survive. They do, as proven by the records of Muriel Lake and several other Alberta lakes which contained no whitefish until stocked by the hatchery. The answer lies in the fact that natural reproduction, as indicated by data from Lake Wabamun, produces approximately 100 times the number of fish that the lake can possibly contain. There must be, therefore, an enormous mortality imposed by competition for food and space. This elimination of the surplus by the environment affects hatchery introduced eggs and fry in precisely the same manner and to the same degree as naturally produced eggs and fry. Only a certain few young fish can become adults; when a hundred times this number is produced naturally, why introduce still more to be eliminated? It is not surprising, therefore, that a few million hatchery produced eggs or fry fail to have any measurable effect on the fishery.

SUMMARY

1. A long term experiment to test the effectiveness of the Alberta whitefish hatchery was begun in 1941, by planting "eyed" eggs in a series of lakes on alternate years. Subsequent year class strengths, determined by samples from

the commercial catch, were then compared.

2. The evidence from the first five years indicates rather strongly that the hatchery supported year classes are no stronger than those not so supported, in a series of five lakes 12 to 462 square miles in area.

3. Preliminary observations on the efficiency of natural reproduction indicate that about 10 per cent of the eggs survive to become fry. This is sufficient to produce roughly 100 times the number of adult fish which a lake can support.

4. "Eyed" eggs introduced by the hatchery survive and produce fry, because several lakes formerly without whitefish but stocked with eyed eggs now support commercial fisheries

5. The failure of the hatchery products is not due to the method used, as the stock introduced survives; natural reproduction provides more than can survive, hence additional stock from the hatchery cannot change the ultimate result.

6. The data and conclusions presented are preliminary, and the experiment will continue for another five years.

FOOD HABITS OF WILD GEESE ON THE GULF COAST OF TEXAS[1]

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Little has been published on the food habits of wild geese in Texas. Bent (1925) and Simmons (1925) made brief general mention of the matter as pertaining to inland Texas, entirely from a qualitative standpoint. Howell (1911) reported on observations in Arkansas, and McIlhenny (1932) and Oberholser (1938) gave accounts of feeding activities in Louisiana. Nothing has been found of a quantitative nature applicable to conditions along the coastal area of Texas.

Most of the food studies by the writer were made from 1939 to 1943, but some subsequent material has been included here. Observations were made all along the coastal country (Fig. 1), but the portion from Corpus Christi to Galveston Bay was covered more thoroughly. Consequently, as supplemented by reports from observers east of Galveston Bay, the material presented is considered representative of the entire area from Brownsville to the Louisiana border, and inland for 30 to 60 miles. Cattle grazing is the principal local land use, followed by farming of cotton, grain sorghums, rice, corn, and various truck crops.

Native vegetation of the Gulf coastal area is largely of grasses, with associated weeds and some scattered timber. Immediately inland from tidewater along most of the coast, there are marsh- and salt-grasses. Next inland,

[1] Contribution fron Texas Cooperative Wildlife Research Unit: Agricultural and Mechanical College of Texas; Texas Game, Fish and Oyster Commission; American Wildlife Institute; and U. S. Fish and Wildlife Service, cooperating.

the coastal prairie supports various species of beardgrass (*Andropogon*), bullgrass (*Paspalum*), smut grass (*Sporobolus*), and panic grass (*Panicum*), and various less common species. From Frederick C. Lincoln of the U. S. Fish and Wildlife Service, and to census figures accumulated by Glazener (1943), Texas has a winter population of wild geese somewhat in excess of 300,000,

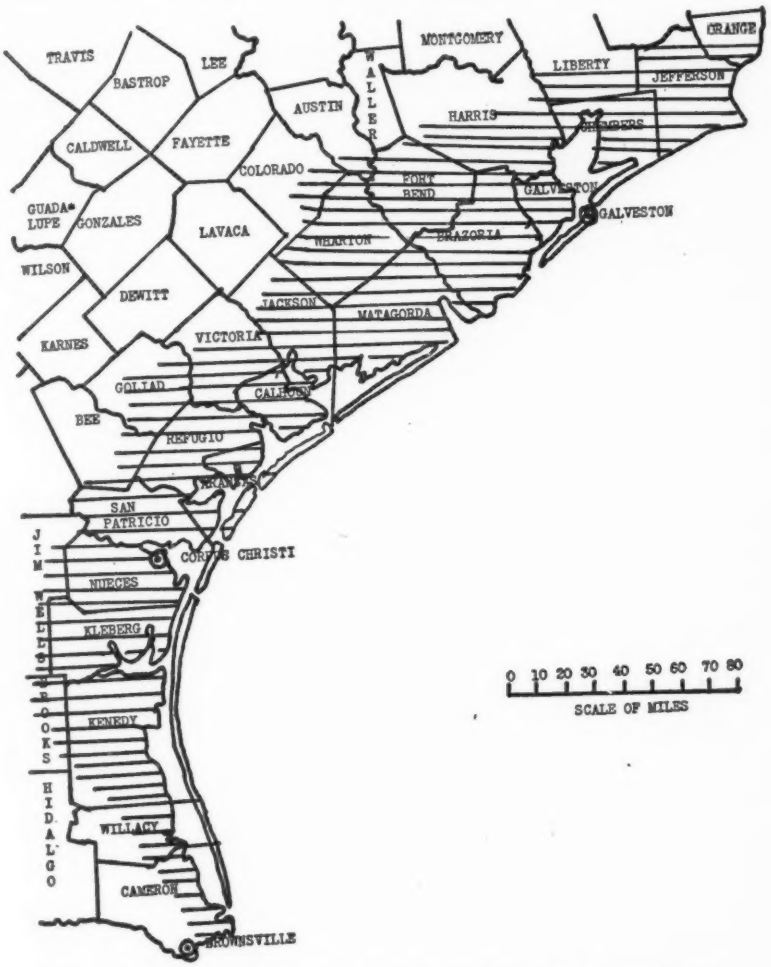

Fig. 1. Winter range of geese (shaded) on the Gulf Coast of Texas.

Refugio to Nueces Bay there is a sparse brush plain that gives way in turn southward to a heavy brush belt reaching down to Willacy County and the lower Rio Grande Valley.

According to correspondence from most of the birds being within the designated coastal winter range. Species present annually are the Canada goose (*Branta canadensis canadensis*), lesser Canada goose (*B. c. leucopareia*), Hutchins goose (*B. c. hutchinsi*), lesser

snow goose (*Chen hyperborea hyperborea*), blue goose (*C. caerulescens*), and white-fronted goose (*Anser albifrons albifrons*). First autumn flights of geese arrive on the coast during the last two weeks of September, with the heaviest movement usually during the first two weeks of October. Departures for the north commonly begin in late February and continue until mid-May.

MATERIALS

The food in 117 gizzards was separated, measured volumetrically, and identified, using methods recommended by Martin and Uhler (1939) and Cottam (1939) to furnish quantitative data. The gizzards were of birds taken in the area between Corpus Christi and Galveston Bay, from October to March, 1939–42. Extensive field observations on goose feeding grounds and interviews with residents of the winter range afforded further information. Droppings were examined regularly to seek a positive correlation between field and laboratory work.

FIELD OBSERVATIONS

Geese normally follow regular daily feeding schedules. When exposed to extreme hunting pressure or other severe disturbance they may become irregular, feeding by night and resting by day. Members of the *canadensis* group usually begin to leave roosting grounds about a half hour before day break, and all are gone by an hour after sunrise. Lesser snow geese, on the contrary, are the last to take flight, and most of them leave "en masse." On dark or overcast mornings the flights of all species are delayed slightly.

Morning feeding usually occurs at distances up to 30 miles from roost sites and continues to mid-morning, then the birds begin moving to a waterhole to drink. The watering period may extend to mid-afternoon, followed by afternoon feeding that continues until dark. Snow geese frequently remain on feeding grounds until after dark, whereas other species seldom are found out so late.

Rice unquestionably supplies more food for geese than any other cultivated crop along the Texas coast. Within the rice belt, from Lavaca Bay to Louisiana, the snow, blue, and white-fronted geese in particular take advantage of the enormous amounts of shattered grain on stubble lands. The writer found lesser Canada geese on rice stubble in Matagorda County on November 1, 1940, and Buster Chamblee of Oyster Lake states that Canada geese made their regular annual appearance on rice land there late in December. Flocks of Canada geese are reported also to feed on rice in Chambers County, but all those observed in Wharton and Colorado counties were on pastures.

Shattered rice remains available to geese all winter, and there is no indication that sprouting of the grain makes it any less desirable as food. As rains fall, buried rice is uncovered by erosive action and adds to the supply. Even half-buried grains are eaten in great quantities, along with much soil; frequently the birds take almost as much soil as grain.

Corn is the favorite cultivated food of the *canadensis* group, and is taken extensively by other species. The region from Lavaca Bay south to Kleberg County produces sufficient corn each year to provide for the geese wintering there. Harvesting results in some shat-

tering of corn in the fields, but most of the food left for geese is of entire ears or small "nubbins" overlooked or dropped from the wagons. As soon as corn stalks have been knocked down or the land plowed, the geese move in; exposed grains are eaten first, then ears with tips showing are pulled from the ground and shredded. Subsequent cultivation of corn land ends its usefulness to geese by January or a little later, and the flocks must shift to other food.

Grain sorghums are grown more extensively over the winter range than either rice or corn, but the geese feed less on sorghums than on the latter. In localities where either corn or rice occur, few or no geese are found in sorghum fields, but where their favored foods are lacking, sorghum fields will draw geese in great numbers if production has been heavy. Such an increase is particularly evident throughout Nueces County where, as a boy, the writer never observed geese feeding on farm lands. Heavy feeding on sorghum was seen near Falfurrias, Brooks County, during 1944 and 1945.

A few other crops afford smaller amounts of food. Flax, a recent arrival in the blackland portion of the central coastal strip, attracts considerable numbers of the *canadensis* group for a short time in late winter, but no other species has been observed to feed upon it. In January 1941, near Austwell, Refugio County, geese clipped four inches of growth from 70 acres of flax during three nights, leaving only short stubs of the plant stems. All species of geese feed on leafy winter truck crops, mostly cabbage and spinach, but the acreage involved is comparatively small. Sudan and Rhodes grasses, as hay and pasture crops, have been utilized in a few cases, as have small grains planted for winter pasture. In the winter of 1944–45, R. G. Smith of Rio Hondo, Cameron County, and others of the locality, reported appreciable feeding on English peas grown on irrigated land. According to observations by Daniel W. Lay for at least five years geese have regularly taken small sweet potatoes left on fields in Chambers County during "digging" operations.

Geese comprise two groups commonly referred to as "grazers" and "grubbers" with regard to their habits in feeding on native vegetation. In grazing, they may take only part of the foliage from plants, or may strip the entire stem, seed heads, or flowers indiscriminately, frequently uprooting and consuming entire plants of the smaller species. Grubbing refers to the tearing out of tubers, rhizomes, and other underground parts of plants growing in wet marsh land. The goose plunges its beak into the mud at the base of a plant and pulls up anything it can grasp. This is continued until an entire plant has been torn from the ground, and often until all plants are removed from a given feeding spot. Lay and Lynch (MS) found valuable muskrat habitat "eaten out" after this fashion by snow and blue geese in marshes of southeastern Texas.

As indicated by Bailey (1928), snow and blue geese customarily frequent marsh areas and are chiefly grubbers, although they do a certain amount of grazing both in marshes and on prairies. The *canadensis* group and the white-fronted geese, by contrast, feed almost entirely by grazing. However, W. D. Bickford of Refugio County reports

having seen these species follow along after grubbers on the Guadalupe River marshes, picking up fragments which the latter had dropped. While the grazing species feed largely on open prairie country, they also clip considerable quantities of marsh vegetation at times.

Along the shores of San Antonio Bay, Refugio County, the writer found geese feeding on stands of saltgrass (*Distichlis spicata*), sea ox-eye (*Borrichia frutescens*), cranberry (*Lycium berlandeiri*), and smooth cordgrass (*Spartina alteniflora*).

In March 1940, at a feeding-resting site sodded with Bermuda grass on the Aransas National Refuge, more than 500 Canada geese were flushed on several occasions. Bermuda grass (*Cynodon dactylon*) over the entire flat showed unmistakable signs of heavy grazing and the abundant goose droppings contained foliage and inflorescences of this grass. Daniel W. Lay reports that in Chambers County flocks of Canada geese feed largely on flats sodded over by Bermuda grass subsequent to overgrazing, and that water hyssop (*Bacopa*) and bullgrass (*Paspalum*) on nearby flats are utilized extensively. Up to the time that the Brownsville Ship Channel was excavated, Charles G. Jones of Weslaco observed flocks of Canada and lesser Canada geese each autumn feeding on cranberries growing in profusion over low, saline flats between Brownsville and Port Isabel, Cameron County. Following the excavation, however, the cranberries began to die out and geese ceased to appear.

At various times in the autumn and winter of 1939, the writer observed geese feeding on stands of glasswort (*Salicornia bigelovii*) and salt cedar grass (*Monanthochloa littoralis*). In 1942, others were seen to take bur clover (*Medicago hispida*), evening primrose (*Oenothera speciosa*), ragweed (*Ambrosia psilostachya*), and wild verbena (*Verbena*). O. F. Hartmann of Refugio County states that he has observed geese feeding on tallow weed (*Plantago*) until their gullets were greatly distended, the birds finally flying away after water. Geese on his farm have consistently stripped leaves from thistle (*Cirsium*), with never any damage to seed or flower stalks.

Snow and blue geese in marsh areas of Aransas, Calhoun, and Refugio counties feed on reeds (*Phragmites communis*), saltgrass (*Distichlis spicata*), smooth cordgrass (*Spartina alterniflora*) sacahuiste (*Spartina spartinae*), bulrush (*Scirpus americanus* and *S. robustus*), cattail (*Typha angustifolia*), smartweed (*Polygonum*), and sedges (*Carex* and *Cyperus*). Upland feeding by the grubbing species of geese was observed mostly during wet weather. On prairie pastures of Calhoun, Jackson, Matagorda, Fort Bend, Goliad, and Refugio counties, there were great flocks of snow and blue geese from January to March, 1941, when the vegetation available included beardgrass (*Andropogon*), bullgrass (*Paspalum*), fescue grass (*Festuca*), lovegrass (*Eragrostis*), panic grass (*Panicum*), bristlegrass (*Setaria*), and smut grass (*Sporobolus*). Those grasses appeared to be taken almost exclusively, although there was an abundance of other food present in the form of clovers, mustards, chickweeds, and parsleys.

LABORATORY ANALYSES

In view of the sources of the goose specimens collected and the various

food materials involved, the specimens were divided into two groups for comparison. The first was composed of specimens from the rice belt, Brazoria, Colorado, Wharton, and Matagorda counties, and the other from the general farming section of Aransas, Calhoun, and Refugio counties. Furthermore, since food apparently varied more with the district inhabited than with the species of goose concerned all species were placed together within each of the district groups (Tables 1 and 2). All of

TABLE 1.—FOOD OF 22 GEESE IN THE COASTAL RICE BELT OF TEXAS.[a]

	Frequency	*Percentage*
Rice (*Oryza sativa*)	18	*96.0*
Bermuda grass (*Cynodon dactylon*)	3	*2.7*
Alga	1	*0.8*
Bur clover (*Medicago hispida*)	1	*0.3*
Undetermined	2	*0.4*

[a] Specimens included:

Lesser snow goose	8
White-fronted goose	6
Blue goose	4
Canada goose	3
Lesser Canada goose	1

the food material examined was vegetable matter. Among specimens from the rice belt, snow, blue, and white-fronted geese had eaten rice exclusively. One Canada goose had consumed some rice, but others of that species had taken Bermuda grass, bur clover, and an alga. The total esophageal content in some white-fronted and snow geese was as much as 80 cc.

Specimens collected in the other coastal section, Port Lavaca to Corpus Christi (Table 2), utilized a wider variety of plant species and displayed a wide difference in the relative consumption of native and cultivated foods. Corn was the principal single item, taken more or less by all species. It was impossible to determine the exact identity of about 40 per cent of the

TABLE 2.—FOOD OF 95 GEESE IN THE GENERAL FARMING DISTRICT OF COASTAL TEXAS.[a]

	Frequency	*Percentage by volume*
Corn (*Zea mays*)	33	*13.7*
Saltgrass *Distichlis spicata*	4	*11.3*
Grain sorghum (*Sorghum vulgare*)	18	*6.8*
Water cress (*Radicula nasturtium-aquaticum*)	17	*5.9*
Cultivated flax (*Linum usitatissimum*)	2	*3.5*
Sacahuiste (*Spartina spartinae*)	3	*3.3*
Panic grass (*Panicum*)	4	*2.5*
Dock (*Rumex acetosella*)	5	*1.9*
Water hyssop (*Bacopa monniera*)	10	*1.7*
Everlasting pea (*Lathyrus pusillus*)	8	*1.1*
Bullgrass (*Paspalum*)	1	*1.0*
Bermuda grass (*Cynodon dactylon*)	2	*.8*
Heliotrope (*Heliotropium indicum*)	1	*.8*
Alga	2	*.8*
Wild carrot (*Chaerophyllum*)	7	*.6*
Smartweed (*Polygonum*)	6	*.5*
Wild parsley (*Cynosciadum*)	2	*.4*
Johnson grass (*Sorghum halepense*)	1	*.4*
Tie-vine (*Ipomea*)	4	*.3*
Ragweed (*Ambrosia psilostachya*)	1	*.3*
Wild cantaloupe (*Cucumis melo*)	2	*.3*
Nut grass (*Cyperus*)	2	*.3*
Wild millet (*Echinochloa colonum*)	2	*.2*
Sorrel (*Oxalis*)	4	*.1*
Fingergrass (*Chloris*)	1	*.1*
Smut grass (*Sporobolus*)	1	*.1*
Marsh elder (*Iva frutescens*)	2	*.1*
Poor Joe (*Diodia teres*)	2	*.1*
Geranium (*Geranium*)	1	*.1*
Bur clover (*Medicago hispida*)	3	*tr.*
Scrambled eggs (*Corydalis*)	1	*tr.*
Unidentified grasses	57	*32.0*
Other unidentified matter	20	*8.1*

[a] Specimens included in this analysis.

Lesser Canada and Hutchins geese	55
Canada goose	12
Lesser snow goose	14
White-fronted goose	12
Blue goose	2

food, but that part was mostly of grasses. Canada geese, ranging over a more varied habitat than other species, had taken 65 per cent of the undetermined material.

Parts of plants found either in droppings or gizzards are indicated in Table 3. Other parts may have been overlooked because of a quicker breakdown in passing along the digestive tract. In addition to these findings, Daniel W. Lay reports that in Chambers and Jefferson counties, members of the *canadensis* group eat leaves of *Juncus*, foliage and inflorescences of Bermuda grass, and grains of rice. Snow geese in the same localities had taken rhizomes of *Distichlis spicata*, *Scirpus robustus*, and *Juncus*, tubers of *Eleocharis quadrangulata*, and rice grains.

TABLE 3.—PARTS OF PLANTS EATEN BY GEESE IN COASTAL TEXAS.

Cultivated rice (*Oryza sativa*)	Seeds
Corn (*Zea mays*)	Seeds
Grain sorghum (*Sorghum vulgare*)	Seeds
Saltgrass (*Distichlis spicata*)	Seeds, blades, stems
Water cress (*Radicula nasturtium-aquaticum*)	Foliage, stems
Cultivated flax (*Linum usitatissimum*)	Foliage, stems
Sacahuiste (*Spartina spartinae*)	Succulent shoots, seeds
Panic grass (*Panicum*)	Seeds, foliage, stems
Dock (*Rumex acetosella*)	Seeds, foliage
Water hyssop (*Bacopa monniera*)	Foliage, stems
Everlasting pea (*Lathyrus pusillus*)	Foliage, stems
Bullgrass (*Paspalum*)	Seeds, blades, stems
Bermuda grass (*Cynodon dactylon*)	Seeds, blades, stems, inflorescences
Heliotrope (*Heliotropium indicum*)	Seeds, foliage
Alga	Filaments
Wild carrot (*Chaerophyllum*)	Foliage, stems
Smartweed (*Polygonum*)	Seeds (achenes)
Wild parsley (*Cynosciadium*)	Foliage, stems
Johnson grass (*Sorghum halepense*)	Seeds
Tie-vine (*Ipomea*)	Seeds
Ragweed (*Ambrosia psilostachya*)	Foliage
Wild cantaloupe (*Cucumis melo*)	Seeds
Wild millet (*Echinochloa colonum*)	Seeds
Sorrel (*Oxalis*)	Foliage
Fingergrass (*Chloris*)	Seeds, blades
Smut grass (*Sporobolus*)	Seeds, blades
Marsh elder (*Iva frutescens*)	Seeds, foliage
Poor Joe (*Diodia teres*)	Seeds, foliage)
Geranium (*Geranium*)	Foliage
Bur clover (*Medicago hispida*)	Foliage, stems
Scrambled eggs (*Corydalis*)	Foliage, stems

SUMMARY

Wintering geese in the coastal region of Texas ordinarily have a regular daily feeding schedule, making one trip to the feeding grounds in the early morning and another in the late afternoon, with a midday rest period at a waterhole.

Food materials from 117 geese were entirely plant materials, including 31 species of flowering plants and an alga.

More than 66 per cent of the identified material was of grasses (*Graminae*).

Rice, corn, and grain sorghums were the cultivated crops most commonly and extensively taken, and practically all the grain so taken was waste picked from the ground.

Saltgrass, water cress, and panic grass were the native species most extensively consumed by geese.

Succulent winter crops of flax and winter truck are sometimes eaten by geese and eventually may require protection at times.

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THE MERRIAM TURKEY ON THE SAN CARLOS INDIAN RESERVATION

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On the San Carlos Indian Reservation in southeastern Arizona, the Merriam turkey (*Meleagris gallopavo merriami*) is associated with forests of yellow pine (*Pinus ponderosa*) which in general are at elevations of about 6,000 feet. In this area there is considerable live oak (*Quercus*) and juniper (*Juniperus pachyphloea*), which in places form extensive stands, and also there are large tracts of grassland. The turkey range on the Reservation probably amounts to 600 square miles or more.

Two long-time local residents stated that 30 years ago the turkey was more plentiful than today, and that flocks containing several hundred birds could then be seen. In the autumn of 1943 local hunters stated that turkeys were more abundant than during the preceding three or four years. They thought that in 1943 the population had built up considerably since the period when the turkey was heavily hunted by Civilian Conservation Corps personnel. The Indians learned to eat and appreciate the turkey as a food in C.C.C. camps, and as a result many Indians began to hunt the bird assiduously. The hunting was heavy because the camps were distributed over much of the turkey habitat. Indians who now work in the high country as fire guards or cowboys still shoot many turkeys at all seasons when opportunity offers.

In the autumn of 1943 I made several trips by car through a 20-mile stretch of yellow pine forest and generally saw at least one or two flocks of turkeys on each trip. On one trip four flocks were seen, totaling about 80 birds; the largest flock contained about 35 turkeys. Along the same stretch of road a

friend saw five flocks numbering more than 100 birds.

Most of the turkeys remain in the pine forests throughout the year, but occasionally a few flocks move to lower areas. Two flocks were seen below the pines at about 4,000 feet altitude during the autumn and winter. One of about a dozen was along Warm Springs Creek in early November, and another in late October and at intervals during the winter along Ash Creek. Oak, juniper, and large cottonwood trees grow in these creek beds. It appeared that food was less plentiful at the lower altitudes than among the pines. Possibly in primitive times, before the days of overgrazing, the food supply at the lower elevations was greater.

HUNTING

In 1943 there was considerable turkey hunting by the local white people, the Indians, and members of a sportsmen's club from the nearby town of Globe. The season extended from October 16 to November 15 and the bag limit for the white hunters was two birds for the season. The turkeys were hunted chiefly along the roads and most of them were killed there. The birds are unafraid of automobiles, but begin to move away when a hunter leaves the car.

Several hunters remarked on the many wounded turkeys that escape during the hunting season. Because of its running ability, a turkey is able to travel far when wounded, unless suffering a broken leg. Some wounded individuals run off with the flock without the hunter knowing that they have been wounded. Most hunters with whom I discussed the subject believed that small caliber rifles resulted in the loss of more wounded turkeys than the use of shotguns; it appears, however, that many wounded birds escape in either case.

On one occasion I observed some Indians hunting with shotguns. They stalked within good range of a group of 8 or 9 gobblers feeding in the early morning. At the first shots all of the turkeys jumped and flapped up for about ten feet, then alighted and ran. Two birds were wounded with the first shots, but while the hunters were shooting at the survivors one wounded bird ran off unseen by the hunters. I followed it for more than a quarter mile before being able to overtake it. There was considerable shooting, but only two turkeys, aside from the one I had followed, were secured. Another wounded bird ran away and could not be found. On two other occasions I saw a bird escape which was wounded by rifle fire. Once, a bird, hit in the small of the back, made fair progress and might have escaped if one femur had not been broken. One hunter said he had fired at turkeys 48 times with a rifle without getting one. Whether any were wounded was not stated but the probability is strong that some were hit. Another hunter stated that he "must have wounded about 50 turkeys without getting one." Certainly many turkeys are mortally wounded, yet escape the hunters. Some of these doubtless are later killed by carnivores or eaten as carrion.

The Indians sometimes shoot turkeys off their roosts at night or at break of day. One Indian said he knew of three roosts where he could almost always shoot turkeys. There is no limit to the number of turkeys an Indian may shoot lawfully, and one of them shot 14 birds

TABLE 1.—CONTENTS OF 24 CROPS OF WILD TURKEY, SAN CARLOS INDIAN RESERVATION, ARIZONA, OCTOBER 16–NOVEMBER 15, 1943.

Food items	Number of crops in which present	Percentages		Parts eaten
		Average volume	Maximum volume	
Marsilea	1	*tr.*	*tr.*	leaves
Juniperus pachyphloea	3	*1*	*1.5*	berries
Festuca	1	*20.*	*20.*	seed heads
Eragrostis diffusa	1	*2.5*	*2.5*	seed heads
Lycurus phleoides	2	*tr.*	*tr.*	seed heads
Muhlenbergia texana	9	*26.*	*80.*	seed heads
Aristida	3	*1.5*	*3.*	seed heads
Leptochloa filiformis	1	*tr.*	*tr.*	seed heads
Boutaloua gracilis	3	*1.*	*3.*	seed heads
Bouteloua curtipendulata	1	*tr.*	*tr.*	seed heads
Grass	7	*4.7*	*16.*	dry stems and seeds
Calochortus	1	*tr.*	*tr.*	
Acorns	4	*4.5*	*16.*	nuts
Eriogoneum pharnaceoides	8	*20.*	*90.*	seeds
Silene antirrhina	1	*10.*	*10.*	seed heads
Descurainia	1	*tr.*	*tr.*	seed heads
Calliandra	13	*tr.*	*3.*	seed
Lupinus	6	*tr.*	*tr.*	seeds, pods, leaves
Indigofera sphaerocarpa	1	*tr.*	*tr.*	seeds
Tephrosia	2	*2.*	*4.*	pods and seeds
Astragalus	3	*10.*	*29.*	seed head
Lathyrus arizonicus	4	*18.3*	*30.*	leaves
Erodium cicutarium	6	*13.2*	*63.*	leaves and stems
Croton	2	*tr.*	*tr.*	seeds
Rhus glabra	2	*1.1*	*1.5*	seeds
Rhamnus	1	*3.3*	*3.3*	fruit
Gaura	1	*tr.*	*tr.*	seed
Heracleum lanatum	1	*tr.*	*tr.*	seeds
Garrya wrightii	4	*23.5*	*50.*	seeds
Evolvulus	1	*tr.*	*tr.*	seeds
Physalis	3	*1.5*	*2.*	seed heads
Ambrosia psilostachya	17	*31.*	*99.*	mainly seeds, some leaves
Viguiera	13	*29.8*	*95.*	heads and seeds
Helianthus annus	8	*26.5*	*95.*	seed heads
Hymenothrix wrightii	1	*1.*	*1.*	seed heads
Agoseris	2	*75.*	*85.*	leaves and heads
Hieracium	2	*tr.*	*1.*	leaves
Tame oats (bait)	5	*62.*	*99.*	seeds (bait)
Grasshoppers and beetles	8	*tr.*	*tr.*	
Pebbles (number)	14	*14.*	*35.*	

during a single morning. If more Indians should take up turkey hunting the population would be quickly depleted unless the Indians restrained themselves by instituting bag limits.

FOOD HABITS

The crops of 23 turkeys killed between October 16 and November 15, 1943, and some gizzards, were obtained from hunters, and also the crop of one turkey killed in March 1944. Assistance in the identification of food material was given by Neil Hotchkiss and A. C. Martin of the U. S. Fish and Wildlife Service, Agnes Chase of the U. S. National Museum, H. L. Mason of the University of California, and Robert A. Darrow of the University of Arizona (Table 1). In a patch of green grass at

Hilltop, 43 droppings deposited between December 21, 1943, and January 22, 1944, were collected (Table 2).

The number of crops and droppings examined are insufficient to provide full information on the food habits in this area, but indicate some important autumn foods. Less than one per cent of the contents were of animal matter; 37 kinds of plants were identified in the crops and droppings. The seed heads of at least eight kinds of grasses had been eaten, the fine seed heads of *Muhlenbergia phleoides* being especially important. The droppings gathered in December and January where the grass had greened up showed that some turkeys then were feeding largely on green grass. During these months, however green, grass was not generally available and, because grasses are closely grazed by cattle over much of the range, this food is now less available than in primitive times. Ragweed (*Ambrosia psilostachya*) was found in more crops and in greater quantity than any other food item. Goldeneye (*Viguiera*), sunflower (*Helianthus annus*), and *Eriogonum pharnaceoides* were also important foods; these plants may have increased under heavy grazing.

Acorns were poorly represented, probably because they were scarce in the autumn of 1943. In the preceding two or three years acorns had been plentiful and probably then were an important food supply. In the spring of 1943 many turkey scratchings were noted among the oaks, indicating that the birds were then feeding on acorns.

Small amounts of juniper berries were found in three crops, and three gizzards contained 1, 52, and 105 juniper seeds, respectively. The seeds were smoothly polished and a few were broken so it appeared that they had been in the gizzards for some time, functioning as pebbles. All of the 43 droppings collected in December and January contained juniper seeds, indicating that the berries had been eaten regularly at that time. An average of five seeds was found in each dropping. The berries contain 3 or 4 seeds each, hence a little more than one berry was represented in each dropping. Juniper is common in the turkey habitat and generally bears many berries so it may be an important food, especially in years when the acorn crop fails. Coyotes and gray foxes also feed extensively on juniper berries, the former almost exclusively at times, which would indicate that this fruit is quite nutritious.

Seeds of yellow pine are apparently a regular winter food of turkeys. Scratchings by the birds were widespread under the trees, indicating that many of the

TABLE 2.—CONTENTS OF 43 DROPPINGS OF WILD TURKEY, DEC. 21, 1943, TO JAN. 22, 1944.

Contents	Number of droppings in which present	Amount	
		Average	Maximum
Green grass blades	43	*95%*	*95%*
Juniper seeds	43	5	19
Pebbles (number)	18	2.7	7
Lupine seeds	8	2.7	5

seeds were being consumed. Three droppings gathered under pines contained only pine seed shells. This food may be the most important factor in making the pines a much sought turkey habitat.

The tame oats found in five crops was eaten at baiting stations used to entice turkeys into traps, a number of the birds having been trapped by the Arizona Department of Conservation for transplanting to other areas.

Because of the heavy cattle grazing at San Carlos, the range possibly cannot now carry the large number of turkeys present in the early days. The availability of turkey food plants such as grasses would be much reduced by close grazing. However if acorns, pine seeds, and juniper berries are the principal winter foods, the carrying capacity may not have been greatly diminished. Heavy grazing actually may have increased some food plants, such as ragweed. With proper control of hunting, a large turkey population can be maintained on the San Carlos Indian Reservation.

TRAPPING WILD TURKEYS ON THE KENTUCKY WOODLANDS REFUGE[1]

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Restocking of eastern wild turkeys (*Meleagris gallopavo silvestris*) on ranges from which they have been exterminated has been attempted by many conservation agencies in recent years. Artificially reared birds have proved unsatisfactory for this purpose, because they lack the "wild" qualities appreciated by genuine sportsmen, and usually mix with domestic turkeys soon after release (Mosby and Handley, 1943). To improve the wild characteristics of "game-farm" birds for restocking, independent experiments were begun in Pennsylvania during 1936, in Missouri (Blakey, 1937), and in Virginia (Mosby and Handley, 1943) by the mating captive hens and wild toms. The results were successful for the purpose, but many conservationists and sportsmen consider that birds so obtained will not perpetuate the wariness of fully wild birds to serve the best conservation purposes. The present paper deals with methods of capturing birds in the wild to restock depleted parts of their former range.

Live-trapping in densely populated areas is considered the best method to obtain and maintain a pure strain of wild turkey, provided care is exercised that pure-blooded birds are being trapped. This method is time consuming and rather expensive, but is justified by the superior quality of turkeys released.

Live-trapping of turkeys was prose-

[1] Suggestions on methods were provided by William P. Baldwin, Jr., Santee National Wildlife Refuge, South Carolina, and Gerald P. Baker, Kentucky Woodlands National Wildlife Refuge.

cuted on the Kentucky Woodlands National Wildlife Refuge which is located between the Cumberland and Tennessee rivers in Lyon and Trigg counties, Kentucky; 33 were taken in the autumn of 1943 and 24 in the autumn and winter of 1944–45.[2] These were released at Mammoth Cave National Park, Kentucky, Noxubee National Wildlife Refuge, Mississippi, and Piedmont National Wildlife Refuge, Georgia.

The Kentucky Woodlands Refuge includes about 60,000 acres of rough, hilly woodlands, approximately 10 per cent of which is cleared. The remainder is covered by an oak-hickory association of trees from 6 to 14 inches D.B.H. in the area supporting a dense population of wild turkeys. The clearings are mostly abandoned farmlands, either kept in cultivation or improved as pastures where light regulated grazing is permitted as a tool in game management.

The only remaining native wild turkeys in western Kentucky exist there because of protection previously given them by the Hillman Land Company and the State of Kentucky. Since the Refuge was established in 1938, the U. S. Fish and Wildlife Service has pursued the same protective policies and has developed the habitat so that turkeys on the Refuge by the autumn of 1944 had increased to about 1,600. An estimated one-third of these were concentrated in 12 square miles near the center of the Refuge where habitat improvement has been most intense and where there is the most fertile soil. Traps were operated in this area where the wild turkey population was estimated to be one to 16 acres. Satisfactory trapping of wild turkeys demands a rather high concentration of birds. Since 1944 the population has decreased due to two poor breeding seasons.

[2] Trapping in 1943 by Lane, and aided by Sylvester in 1944–45.

HABITS AFFECTING TRAPPING

Trapping may be undertaken from the time when the poults are mature enough to withstand handling (about mid-September) until the flocks break up in late winter just preceding the breeding season. After mid-December the trapping time per bird caught increases so that the operation may be impracticable; hence the period from September 15 to December 15 is recommended for this work.

Poults can be trapped in greater numbers than mature birds. A hen will lead a brood to the most readily available food and sometimes visits a baited spot twice daily. During the recommended trapping period, the poults are more carefree and tolerant of changes in the surroundings than when older. Thus, they are easily baited, often disregarding the hen's warning "kelks" and entering a trap when she is vainly trying to call them to safety.

Another advantage of trapping during the autumn is that the usual weather then is fairly uniform, which facilitates prediction of flock movements. During stormy and changeable weather the turkeys vary their habits and roosting hours. In the winter of 1944–45 all catches were made on days preceding cold rains. During the winter wild turkeys apparently sense the approach of a storm that will affect their daily cruising range, and feed greedily on the day before.

We found it easier to trap adult gob-

blers than hens, the former being less cautious and seem desirous of obtaining food in the easiest way. Flocks of gobblers frequently will visit a bait spot to fill their crops the first thing in the morning after leaving and the last thing in the evening before returning to the roost. Their roosting sites may be changed but they often use those near the bait. Only two adult hens were caught in two trapping seasons. They are suspicious of any change in the surroundings and may take bait outside a trap but refuse to enter. Flocks led by a hen are more difficult to trap than those led by a gobbler.

PREPARATORY MEASURES

A trapping site should be selected with care. The preferred location will depend on the habits of the individual turkey flock and its use of the range, the local topography and cover, and the type of trap to be used. Bait spots were more successful when near natural feeding areas such as fields of bluegrass, winter grains, lespedeza, or soybeans. For winter trapping, sites near fields of winter wheat are preferable, as turkeys regularly eat such green food. Old logging roads and small openings in the woods are also favored spots. A trapping site is more apt to be successful if located near a natural barrier so that the flock must pass it on the way from roosting cover to a feeding territory. Streams, lakes, steep hills, and brier or thick brush patches are all barriers that tend to restrict flock movements. Turkeys do not like to venture into tall grass or weeds wet with dew or rain, hence the vicinity of the bait spot should have only a sparse herbaceous cover.

The bait spots should be thrice the number of traps planned. Some baited locations may prove unattractive or may be used only irregularly. At other spots the flocks may be frightened away after having taken bait for a considerable time. Extra bait spots also are desirable because new trap sites are needed after catches are made, it being possible to make only one catch a year in many of the traps.

Before a trap is constructed, the turkeys are baited near the proposed site so as to accustom them to feeding on artificial bait in that vicinity. Of the various baits tried, wheat proved the most suitable. Corn, vetch, oats, soybeans, sunflower seed, chicken scratch feed, and Korean lespedeza (Lane, 1944) were tried singly and in various combinations with less success. Large seeds such as corn and beans attract deer, squirrels, and raccoons, while the small seeds draw song birds to the area.

Baiting should begin in late July or early August, when distribution of food three times per week will accustom the turkeys to taking the bait and familiarize them with the site. Sometimes a flock will take bait more readily if some wheat or oat straw is strewn with it. Making false turkey scratchings in the leaves also is helpful. Thinly scattered lines of bait (up to 100 feet long) leading to the site may aid the birds in finding the main supply. Such decoy lines should be discontinued after a flock begins to take bait at the site. Daily baiting should begin about September 1, so the flocks will be "anchored" quickly to the site and take the bait daily. This "anchoring" is more difficult during years of abundant natural food than in those of diminished supplies.

Uneaten bait may sour, mold, or sprout on warm moist days. Such mate-

rial should be carefully removed and fallen leaves scattered over the area. To prevent souring, the flock size should be determined and only a corresponding supply of bait provided. Leaves at the bait spot interfere with rapid feeding by turkeys, which thus will be required to remain longer at the site to fill their crops. Yet, this may be helpful after the trap has been built, for then more birds may enter the trap to procure food. Turkeys do not take old bait so readily as new. If deer find the site and start eating the bait, human urine around the bait or on nearby shrubbery will serve as a deterrent without bothering the turkeys.

When a flock of birds is "anchored" to a site, construction of the trap may begin. This is a slow, tedious job, as the trap must be built in stages. The material used and the specific construction procedure depend on the type of trap. Usually one or two sides are partly built and construction then stopped until the birds become accustomed to feeding nearby. The next stage is to add the top. If to be of wire mesh, only a part should be built the first day, lest the birds fear feeding under the wire—turkeys hesitate to go under anything. Although not yet thoroughly tried, a good construction procedure is thought to be building of the top at first so the birds may become used to feeding under it without obstructions on the ground. Both sides and top of one trap were made the same day, and although the site was frequented by a flock of 40 to 50 birds, few fed into the trap. Most of the flock ate bait only on the outside, stopping in line at the open door. The ends are added last, after the birds regularly feed in the partly completed trap. The most satisfactory results were obtained by making drop doors for both ends so that the birds fed into the trap from both.

TYPES OF TRAPS

The two types used were automatic and manually operated. Automatic traps include those preventing escape after the birds once enter a comparatively small opening. The manual type requires an operator to release a trigger to close the trap doors.

AUTOMATIC TRAPS

Automatic traps used were fitted with various types of entrances: single funnel, double funnel, and trench. The traps were built of logs, of two-inch poultry netting, and of a combination of these materials.

For practical purposes, the automatic type of trap proved unsatisfactory, as only a few birds entered on any one day. Such a trap requires two trips daily by the operator to retrieve the catch, as holding the turkeys longer is inadvisable. A bird may injure itself fatally in trying to break out of the trap if captivity is prolonged. Other objections to the automatic type of trap include high mortality from predators and the longer time required to get the turkeys used to the trap and to enter. These traps should not be visited more than twice a day, one visit being after sundown. If the birds remain overnight in the trap, predators may enter and kill them. A desirable feature of the automatic trap is that it will catch a few birds without alarming the entire flock, which may later return and be trapped.

A funnel trap consists of a covered enclosure, at least 12 feet square, with a wire funnel extending into it. The fun-

nel is 12 inches wide and 22 inches high at its smallest point (Baldwin, 1943), and is collapsible. Once the turkey follows the bait through the funnel and finds itself inside the pen, the bird tries to escape by running around the sides, jumps on the unsupported funnel netting, and causes the latter to collapse and close the trap. Two funnels were tried on one trap in an effort to catch more birds at one trapping, but the scheme was unsuccessful. Six were caught on four different days in one single-funnel trap during 1943.

The trench trap requires turkeys to take bait while going up hill. A trench about 10 feet long and two feet wide, is dug in the side of an embankment so that the trench ends in the center of the trap which is on the top of the embankment. Within the trap the trench is covered with small poles and dirt for a width of three feet adjacent to the wall. The birds enter the trap by feeding up the trench, through the tunnel made by covering the trench, and out the opening at the center. When a bird finds itself inside a pen, it runs around the sides, and over the covered part of the trench, keeping away from the center, and does not find the open end of the trench.

The trench trap should be constructed gradually. The back wall and the covering over the trench should not be added until the birds enter the tunnel freely to take the bait. The turkeys then can leave through the open back side, which should not be closed until the trap is ready to operate.

The funnel trap is an old-fashioned type used commonly in the past by poachers, who considered trapping successful if they caught only a few birds in one winter. This type of trap was highly recommended by all "old timers," but proved unsuccessful in our work.

MANUALLY-OPERATED TRAPS

These traps have been constructed of poles or of poultry netting. Those made of poles are dark and slow to build. Before the top is put on, the turkeys often fly over the sides and do not become accustomed to using the door. This makes it difficult to get the birds to use the doorway after the top has been added. Furthermore, adding a pole top is a slow job, and the flock may not feed in the trap because of the changes produced. A wire top on a pole trap sometimes proves more successful.

The most satisfactory trap used on the Refuge was of two-inch poultry netting, supported on trees when possible (Fig. 1). For trapping in early autumn the wire is painted green, and brown for winter trapping, to blend with the dead leaves. This partly camouflages the trap, and produces less change in the natural surroundings. The fewer posts and support poles required, the better are the chances of catching turkeys, as poles are noticed by the birds. When small trees are used for supports, they should be anchored or guyed by wire to other trees to prevent movement by the wind. Swaying of the trees shakes a wire trap and makes the turkeys suspicious so they will not feed beneath it.

The wire sides should be slightly loose so as to give upon pressure and lessen the injury to the captured birds. The top is laid on by working from each side toward the middle, adding the center piece last. By first applying

narrow width next to the side walls, the turkeys can feed through the middle of the trap and still not be under the top. When the birds begin to take bait under the covered portion, the remainder of the top may be added.

fastened on each side of the doorway. A light pole is then fastened to these vertical guide wires on the outside of the door so that the pole slides up and down easily. As the door is raised into position, the pole is pushed to the top

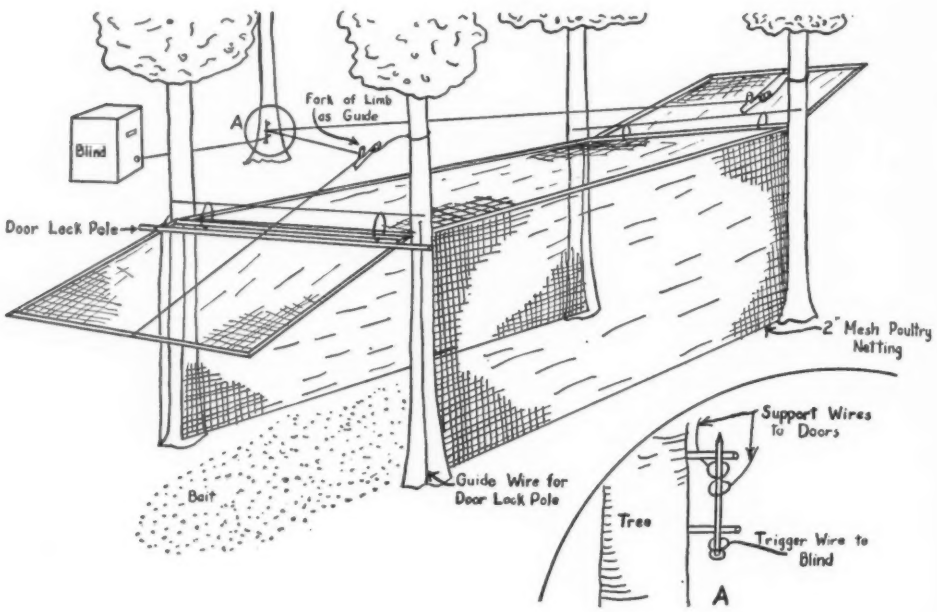

Fig. 1. Successful drop-door trap for wild turkeys. Dimensions vary with the spacing of available trees (see text). A. Details of metal bar trigger made of nails.

Traps with doors at both ends are most satisfactory. The open ends allow the turkeys to feed through the trap without becoming alarmed. Each door is swung from a wire support at the top of the trap, and then held horizontally by a guy wire. When the door drops, it is likely to knock any birds near the entrance into the trap. The wire holding up the door is attached to a metal bar trigger (Fig. 1A); a pull on the trigger cord releases the door. To prevent the birds from escaping by pushing against the door, a vertical wire is

of the trap and supported by the door. When the door is released, the pole drops and holds the door fast.

The size of a trap depends upon the spacing of trees used as corner supports, being 10 to 16 feet wide and six feet high; the most successful traps are two to six feet longer than wide. If a trap is long and narrow, the birds do not feed through it. Lower or narrower traps were not successful, and a large trap is more successful than a small one.

The poultry wire trap and all other observer-operated traps require a blind

near one side of the trap, so that both doors can be observed easily. A well-constructed blind can be within 30 feet of the trap, but preferably is at a greater distance. The blind should be in position when trap construction begins so the birds will become accustomed to it, but may be built at any time up to 10 days before a catch is anticipated.

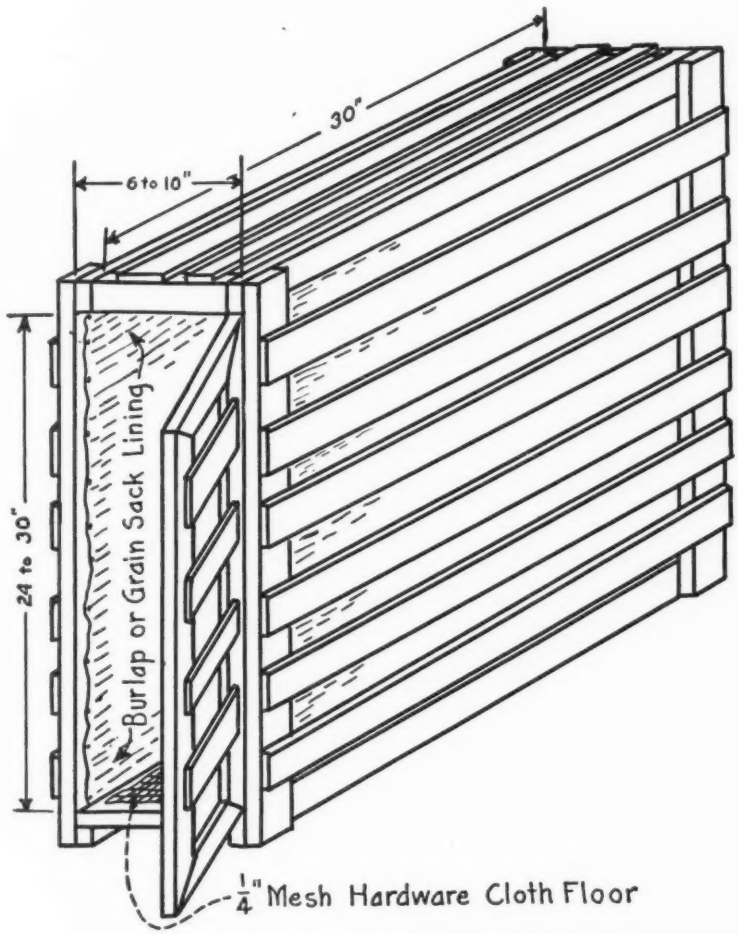

Fig. 2. Crate for carrying individual wild turkeys.

Almost any type of well-camouflaged blind will serve, but it is better if fairly large and comfortable. The observer should enter the blind at least an hour before the flock is expected, preferably before daylight. When a flock approaches, he must be absolutely still (and a flock has been observed feeding at a bait spot for one hour and 40 minutes). If the birds see the slightest movement, including the slow turning of the observer's head, they become wary and leave. Being absolutely quiet for so long

a period is a great strain on the observer. Often he must watch a few birds enter and leave the trap several times before deciding that the maximum number of birds are within and that he should pull the trigger. After the doors drop, the observer should remain within the blind until any untrapped birds leave the area without being further excited and the trapped birds stop fighting the trap.

OTHER TRAPS

Two other types of traps requiring an observer are the rush trap and the drop trap. The former has one open side and may have lead-in wings of hog-wire fencing. When the turkeys feed into the trap, the observer runs toward the entrance, cornering the birds inside. Since there is possibility of injury to the birds in the use of this method, and some turkeys may escape while the observer is catching a few, this trap is not recommended.

The drop trap is suspended on a pulley over a bait spot and quickly lowered and dropped when the birds are feeding beneath. Use of this type seems limited to the autumn when the leaves make the trap less conspicuous. After the leaves had fallen, turkeys would not bait under a wire drop trap suspended 15 feet above the ground.

A drop trap of fish netting, with wire stays to maintain the shape and a few weights to hold it down, seems a desirable type. During 1943 an old net was used successfully, but the turkeys broke through the half-rotten netting and escaped. Twine for new nets was not available during the war period. Drop traps of wire were too heavy and too obvious to the turkeys.

TRANSPORTING TRAPPED TURKEYS

After turkeys have been trapped, they are cornered and put into individual burlap bags, carried in the bags to a waiting truck, and there transferred to carrying crates. While in the bags, care must be taken to insure enough head room for the birds and that particles of loose burlap fuzz or feathers do not lodge in their mouths and choke them. If the birds begin to breathe heavily and rapidly, they should be given more air and their mouths inspected for foreign objects.

Although five game-farm turkeys often are transported in one large crate (Mosby and Handley, 1943), and a 20-bird 4-compartment crate (each compartment 12 inches wide by 3 feet 9 inches long) was developed by Blakey (1945) for the Rio Grande Turkey (*M. g. intermedia*), multiple crates have been unsatisfactory for wild birds from the Kentucky Woodlands Refuge. During 1943 eight died in transit in such crates. Broken wings are a common cause of mortality in wide multiple crates.

In 1945 satisfactory individual crates were constructed (Sylvester, 1945), and made narrow enough so that the turkeys cannot stretch their wings out. These crates are so small and light in weight that one man can handle them easily. Each is 6 to 12 inches wide, 30 inches long, and 30 inches high, inside measurements (Fig. 2). The six-inch width is satisfactory for poults up to about six months of age. When seven to nine months old they are best carried in crates 7 to 8 inches wide. A crate 10 inches wide is large enough for a full grown adult, and the bird can even turn around in this narrow width. The

crate is of such a length that the tail feathers are not bent or broken. The floor is of ¼-inch hardware cloth, allowing the more or less liquid droppings to pass through and leave the crate clean; the mesh floor also provides ventilation. The sides and the top are lined with burlap or grain bags, which provide ventilation from all sides. It is extremely important to have sufficient ventilation for each crate, especially during long journeys. Besides providing for breathing, an abundance of cool air prevents the birds from becoming overheated. The resiliency of the bag lining prevents injury to the bird when it jumps against the crate.

The frame of the crate is of 1×2-inch lumber to which the sacking is fastened; the outside is covered with laths. The hardware cloth floor is fastened to the upper surface of the bottom frame, and a door at one end is hung from the side on butt hinges and fastened with a hook and eye.

With this individual carrying crate, each bird can be transported separately, with less confusion. The bird can be reached easily for banding or examination and, when returned to its crate, soon calms down. When to be released, the door is opened and the turkey walks out and flies away.

The excitable wild turkeys seem unable to digest food satisfactorily in captivity. A hen which was trampled to death in a crate during 1944, had the crop full of bait, although it died about 18 hours after capture; none of the bait had passed into the gizzard. Hence it seems inadvisable to hold trapped birds several days before release.

Before starting on a long journey, time should be allowed for the birds to settle down and become reconciled to the crates in a quiet place. If the release point cannot be reached on the day the birds are trapped, it is advisable to transport them during that night; this simulates their normal roosting period and they are not active. They then can be released at daybreak, less than 24 hours after capture.

In transit, the birds should be kept cool and receive plenty of fresh air, but drafts, especially on their backs, should be avoided. There is more danger from overheating the turkeys than from keeping them too cool. No exhaust fumes from an automobile should enter the compartment containing the birds, as they are very susceptible to carbon-monoxide poisoning. Shipments by express are unsatisfactory because they involve too much handling and delay.

RELEASING THE TURKEYS

It is most satisfactory to release the birds at daybreak in a clearing at least 100 yards from the forest in suitable turkey habitat. To avoid exciting the birds unduly, few persons should be present. The doors of all crates should be opened at once so the entire flock will remain together. Making the release in an opening gives the birds opportunity to fly before entering the forest. This permits them to recover a sense of balance and regain use of their cramped muscles before flying through the woods. Birds released in a forest have flown into tree trunks and been killed before they had regained their sense of equilibrium.

SUMMARY

Live-trapping of native wild turkeys is a most desirable method of obtaining

birds for restocking, but is time consuming and costly.

The turkeys must be accustomed to taking bait regularly, then a trap must be built slowly at the bait site so that the surroundings are not changed sufficiently to alarm the birds. If built too rapidly or some unnatural object is left near the trap, the turkeys may stop taking the bait and all time and effort will be wasted. Turkeys are wary of feeding under any structure, even if 12 feet above the ground, hence great care must be taken in putting the top on a trap.

Automatic traps have not been successful, because few birds are caught at one time. The mortality among birds caught in such traps is high because predators may enter the traps and kill the turkeys confined there.

The most satisfactory trap is of two-inch poultry netting and is approximately 10 feet wide, 15 feet long, and 6 feet high, with a swinging door at each end. This allows the birds to feed through the trap. An observer is required to drop the doors when the birds are within the trap.

It is best to release wild turkeys within 24 hours after being trapped. Narrow individual carrying crates reduce the mortality in transporting the excitable wild birds.

Live-trapped eastern wild turkeys are more excitable than game-farm or wild pen-reared birds. They require more careful handling and should not be held captive longer than necessary.

Trapping wild turkeys is a full-time operation, requiring a patient, skillful, and observant trapper with knowledge of the habits and peculiarities of these birds. He needs a special interest in his job and must expect long and irregular working hours.

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ELECTRIC INCUBATOR FOR GAMEBIRD EGGS

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A small homemade electric incubator, with capacity for 70 pheasant eggs (Pl. 21) has proved efficient for certain experiments requiring accurate temperature control, and for small-scale propagation of pheasants. This unit can be built by an unskilled workman with materials costing about $6.00. The incubator was designed and used successfully by W. C. Sanderson of Law-

rence, Kansas, to hatch the eggs of poultry and game birds. Slight changes in design were made by the writer to facilitate temperature control for laboratory work. Otherwise the unit is identical with the original model. Mr. Sanderson has kindly given permission to describe his incubator.

INCUBATOR BODY

The incubator is double-walled, the outer portion consisting of ¼-inch plywood. The inner wall is made from a standard 10-frame bee hive body (19⅛×16¼×9½ inches); a new hive should be used, free from warping and having tight-fitting joints.

After the hive is squared and nailed together, pieces of white pine about 1 inch wide are nailed along the bottom of both sides and one end to provide a depth of 10½ inches. The lower portion of the remaining end is removed to leave an opening 7 inches deep and of full width for the door (Fig. 1).

Strips of soft wood, ⅝ by ¾ inch, are tacked along the top, bottom, and corners of the body, and on the top and sides of the door opening, to serve as bases for the plywood covering. The ⅝-inch space between the walls is filled with rock wool or spun glass packed lightly to prevent settling. Felt weather stripping is tacked on the upper edge of the body and around the door frame before the lid and door are mounted.

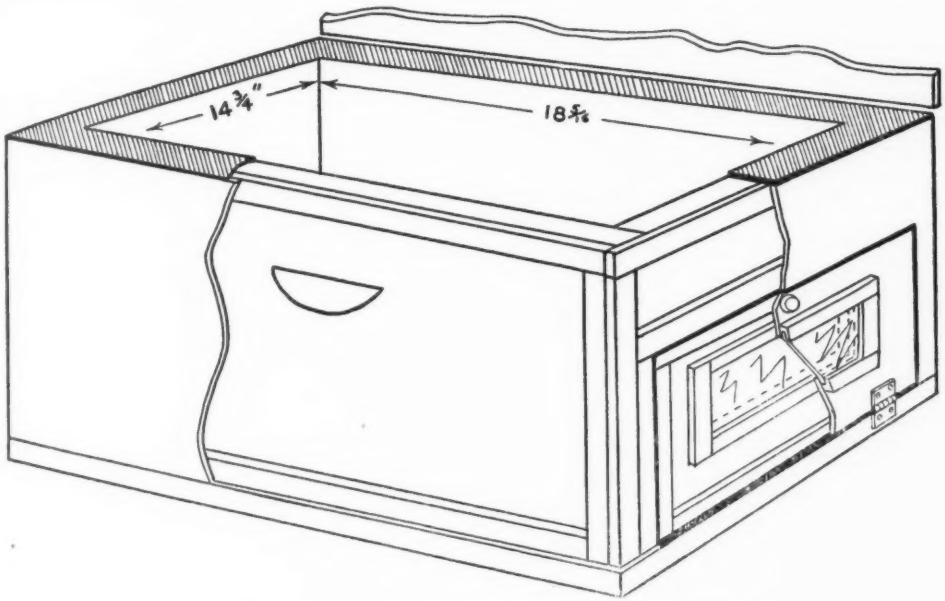


Fig. 1. Incubator body, showing double wall and space for insulating material.

The cover and bottom are of ¾-inch plywood boards, cut to match the outside measurements of the body. The upper and lower edges of the body should be smooth so that these pieces

will fit tightly. The bottom is nailed on and, after the thermostat, heating unit, and wiring are installed, the lid is mounted on the body with three hinges along one side of the top. Four hook-and-eye fasteners, two on the side and one on each end, keep the lid closed tightly when in use.

Four ⅜-inch air intake holes are drilled in the bottom, each 3 inches from the corners and equidistant from the sides. The legs (1½×1½×6 inches) are nailed to the bottom at the corners.

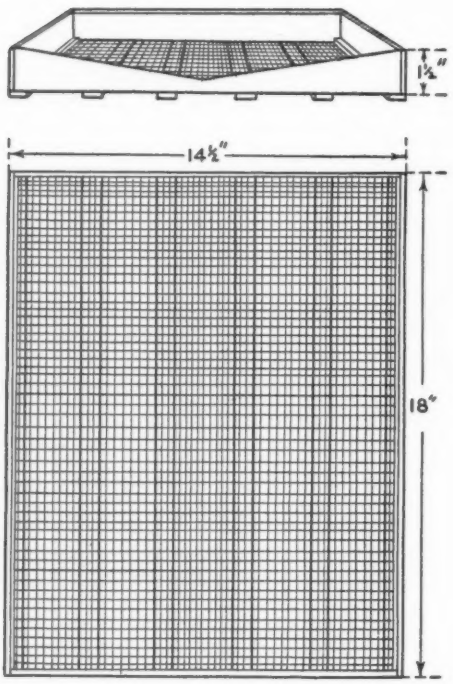


Fig. 2. Egg tray with hardware cloth floor and supports for egg turning grid.

The door, like the body, is double-walled and insulated (Fig. 1). The window consists of two pieces of glass, each 2¾ by 8 inches, separated by an air space. The inner edges of the door should be beveled slightly to fit snugly against the felt insulation when closed.

EGG TRAY

The egg tray (Fig. 2) is of ¼-inch plywood strips and slightly smaller than the inside of the incubator body to permit of easy removal. For pheasant eggs, or larger eggs, the inside depth of the tray should be 1½ inches. A wide triangular piece is cut from the front to allow an unobstructed view of the eggs from the window.

A smooth piece of hardware cloth is fastened with small staples to the bottom of the tray to form a level surface for the eggs. A strip of plywood ¼×½ inch is laid along each side of the tray, above the hardware cloth, and nailed to the bottom to hold the metal egg turning grid ¼ inch above the wire bottom.

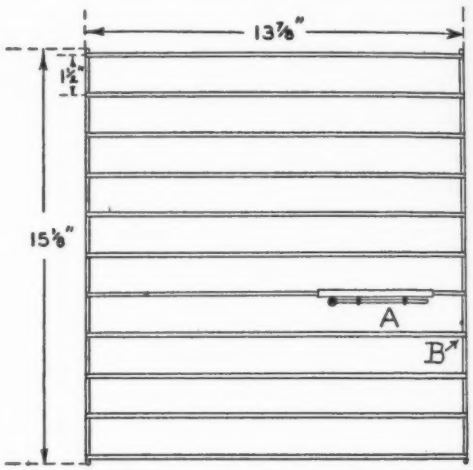
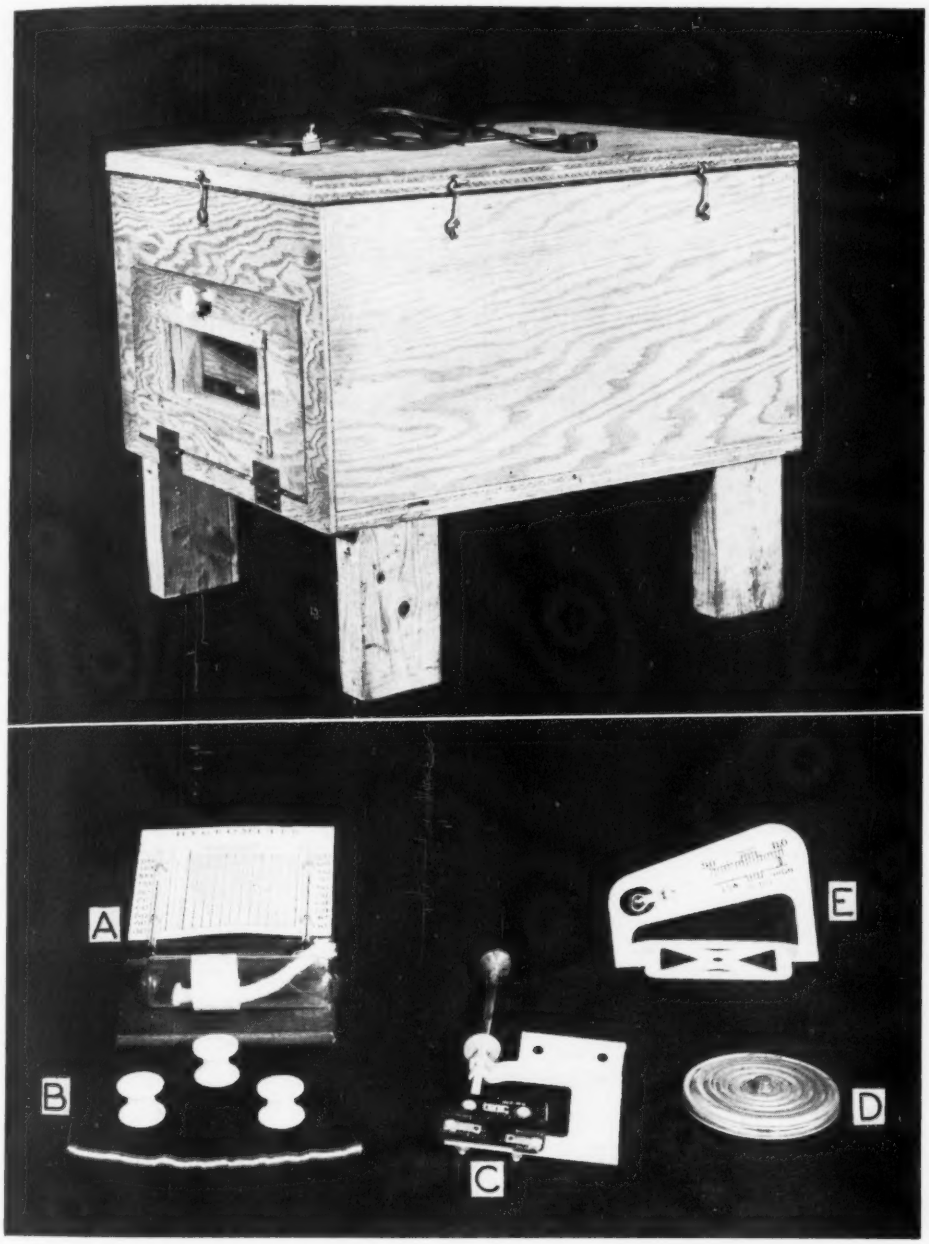


Fig. 3. Egg turning grid. *A*, thermometer soldered on fifth wire of grid; *B*, steel rods joined by high temperature (silver) solder.

The egg turning grid (Fig. 3) is 15⅛ inches long and slightly narrower than



The Sanderson incubator and equipment used in construction. A, hygrometer; B, nichrome heating coil and insulators; C, thermostat; D, thermostat wafer; E, thermometer.

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the tray. This allows it to be moved lengthwise in the tray for about 2½ inches, sufficient to turn the eggs 180 degrees. Steel welding rods (⅛ inch) were used to construct the grid; the 11 cross rods were silver-soldered in shallow notches filed at 1½-inch intervals in the longitudinal rods. For the egg turner shown here, however, a piece of 1½×6-inch mesh poultry fencing may be substituted.

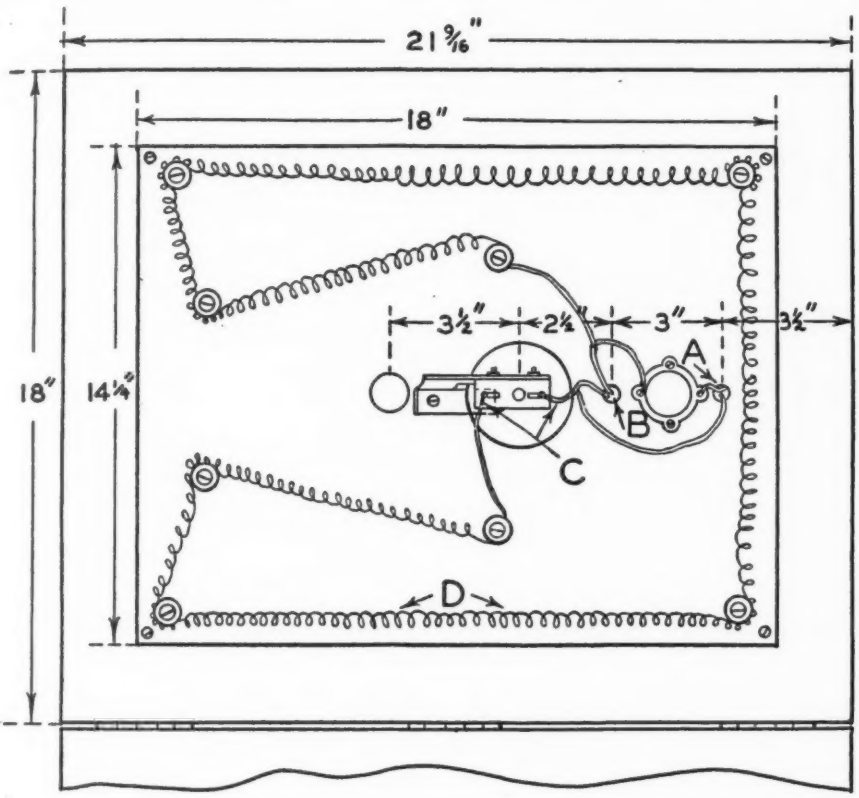

Fig. 4. Under side of lid, with reflector, thermostat, and wiring. A, Wires to inspection light switch; B, 110-volt leads; C, connections to thermostat; D, nichrome heating coil (125 watts).

THERMOSTAT AND HEATING UNIT

A piece of bright sheet tin, slightly smaller than the inside of the body is mounted over a sheet of asbestos on the under side of the lid to serve as a heat reflector. Four holes through the lid and reflector (⅜, ⅜, 5/16, and 1 inch in diameter) are respectively for wires to the inspection-light switch, 110-volt circuit leads, thermostat adjustment screw, and air vent (Figs. 4, 5).

The thermostat is mounted on a wooden or metal base deep enough so the bottom of the thermostat switch will be about ⅜ inch above the eggs when the lid is closed. If the incubator is used for pheasant eggs (average diame-

ter about 1⅜ inches) the bottom of the thermostat switch will be about ¼ inch above the top of the egg tray. The thermostat adjustment screw should extend through the lid. The screw furnished with the thermostat was too short and was replaced with one 6¾ inches long (Pl. 21, C).

The wiring diagram and hookup of the 125-watt nichrome heating element are shown in Figure 4. In stretching the heating coil to the required length, care should be taken to space the turns of wire evenly to insure uniform output of heat throughout its length. An incubator thermometer (Pl. 21, E) is mounted on the fifth wire of the egg turning grid with the bulb as close as possible to the thermostat switch without striking the latter (Fig. 3) when the tray is removed. The base of the thermometer is cut off and the legs soldered on the rod of the egg turner; care must be taken to avoid overheating the thermometer. The center of the bulb should be level with the top of the

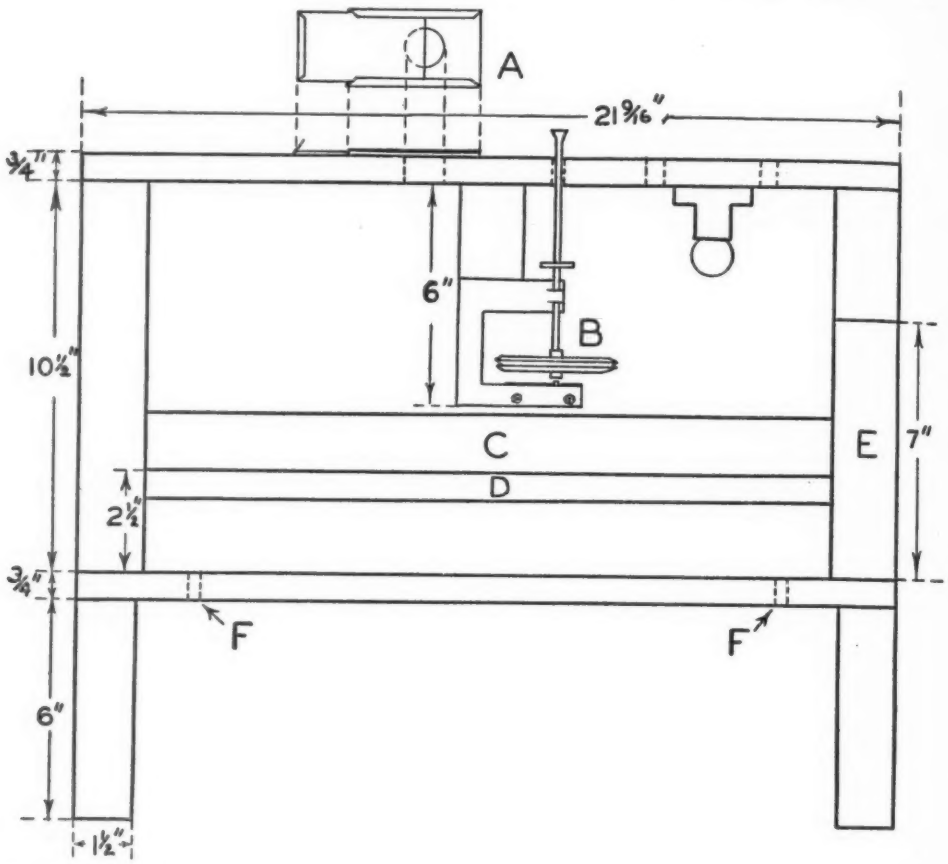

Fig. 5. Sectional profile of incubator. A, air vent shutter; B, thermostat with expansion wafer in place; C, egg tray; D, slide for tray; E, door; F, air intake openings.

eggs. The mercury tube may be inclined upward slightly to facilitate reading from the window.

CONTROL OF HUMIDITY AND AIR

Careful studies of the requirements of pheasant eggs (Romanoff, Bump and Holm, 1938) showed that with a constant temperature and air movement, best results were obtained when the relative humidity within the incubator was about 70 per cent during the first two weeks of incubation and 60 per cent thereafter. An incubator hygrometer (Pl. 21, A) should be used to determine the relative humidity in the incubator.

Moisture is supplied by keeping a flat (pie) pan partly filled with water on the incubator floor below the tray. The amount of evaporation may be increased by placing one or two small sponges in the water. If the relative humidity of the room is high, the water pan may be removed temporarily.

The flow of air from the intake openings through the air vent is regulated by the adjustable shutter on the lid. To conform with the oxygen requirements of pheasant embryos (Bailey and Nestler, 1945), the shutter may be kept about one-fourth open during the first week, one-half open during the second week, three-fourths open through the 20th day, and wide open thereafter.

OPERATION

An inexperienced operator should consult standard publications on the incubation of pheasant eggs, but some suggestions may be helpful. The incubator should be in a room where there are no strong drafts and where the temperature does not vary greatly from 70° F. The basement of a dwelling often will be the most favorable place as to temperature and humidity. The incubator should be level and firmly settled.

Experience with the Sanderson incubator indicates that the optimum temperature for pheasant eggs is 100.5 to 101° F. through the nineteenth day and 100° F. thereafter. Before setting the eggs, the incubator should be in operation for a minimum of 24 hours with the air-vent shutter wide open to dry the interior and ensure that correct temperature is being maintained.

Individual eggs sometimes fail to turn properly when the turning grid is moved, hence it is well to place distinguishing marks (such as "o" and "x") on opposite sides of each egg.

Hatches of pheasant eggs with this incubator have varied, depending chiefly on the quality of eggs used, from 55 to 90 per cent after candling, indicating that it is capable of efficient work. The young pheasants, after hatching, have usually been strong and active.

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BEAVER MANAGEMENT IN THE NORTHERN BLACK HILLS OF SOUTH DAKOTA

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Information on the early history of the beaver (*Castor canadensis missouriensis* Bailey) in the Black Hills of South Dakota is meager, but it is well known that at the time of Custer's expedition in 1874 beaver dams were so numerous that the troops often had trouble in finding places to cross the streams. Old residents recall hearing their grandfathers or fathers tell of the numerous beaver and dams; nearly every stream had beaver. The remains of many of these dams can still be found in the valleys of the region. Ransom (1912)[1] says, "By 1855 the fur trading days were about over in the Dakota field." The big rush of settlers into the Northern Black Hills did not occur until 1876 when gold, not fur, was the motivating force.

As further evidence of the decline in beaver, the first law protecting them was passed in 1887 and fixed a closed season for five years. In 1889, a two year closed season was provided, and a law enacted in 1909 protected them from April 1 to November 15, unless the animals were doing damage to property. This law also required an out-of-state trapper to purchase a non-resident license. In 1917 the law was amended to protect beaver from April 1 to December 1, and also required a resident license except for land owners and for boys under 18 years of age. In 1925 a law was enacted to prohibit the taking of beaver except when damaging ditches, dams, etc., and then only under a permit by a State Game Warden. It also authorized wardens to permit the taking of beaver on public lands when damage was being done. From 1935 until the present, the Game and Fish Department has been issuing permits to land owners to trap a certain number of beaver if inspection by a warden showed the beaver to be doing damage. When the permit holder has finished trapping, the pelts are divided between him and the State. The permit-holder's share of the pelts are tagged with metal self-locking seals and he is given a written shipping permit to legalize his pelts. If the land owner does not want to trap the beaver under these conditions but desires their removal, department personnel will trap the beaver in the summer or trap and pelt them during the winter

What happened to the beaver between 1874 and the early 1900's is not well known; it is generally believed they were removed by trappers. By 1927 they were so nearly exterminaed in South Dakota that the Game and Fish Department started a program to rehabilitate them in the area. By 1936 the beaver were partly established and

[1] Ransom, Frank L. 1912. The Sunshine State—A History of South Dakota. Mitchell, South Dakota, The Educational School Supply Co., 171 pp.

at the present they are well distributed throughout the region.

This repopulation in the Northern Black Hills has been accomplished by a program of moving beaver from well populated sections to new sites. The men doing the work and the co-operating agencies have carried on this rehabilitation program not for the beaver alone but as a multiple-use development. In establishing new colonies, six objectives have been accomplished: production of beaver; conservation of soil and water; producing watering places for livestock and wildlife; providing habitat for other fur bearers and trout; making water more accessible for forest fire control; and stabilizing stream flow.

To maintain these objectives for as long as possible, it is essential that the life of each beaver colony be prolonged to the maximum. This has been accomplished by a harvesting practice which maintains a minimum number of beaver at each colony so that the existing food supply will continue over a long period. The excess beaver are either harvested alive in the summer and transplanted to new sites, or pelted in the winter when new stocking is not needed.

In the period from 1936 to 1944, with aid of the U. S. Forest Service, Civilian Conservation Corps, Boy Scouts, and sportsmen, 136 beaver were planted at 34 artificially prepared new sites in the Northern Black Hills. The success of these plantings is evidenced by the fact that the beaver established themselves at all but three sites where they were liberated. It is believed that this success was due largely to the choice of sites and the preparation made on them before the animals were introduced. The preparation consisted of constructing a small dam and a temporary bank lodge at each new location.

In contrast with the results of releases at prepared sites, 259 beaver were live-trapped and released in the same area (of about 700 square miles), but without artificial site preparation. Very few of the latter beaver stayed at the points of release. Many established themselves at self-chosen sites, but a few moved around and some returned to their home locations.

Between 1942 and 1944 a total of 100 of the released beaver were ear-tagged. Small monel-metal fish tags were used, duplicate numbered tags being placed in each ear. Live traps were used in capturing the beaver and it was easy to tag the animals. The beaver were merely crowded into a corner of the trap until an ear protruded through the mesh of the trap and was accessible for tagging. Of these tagged animals, 84 were released without site preparation and 16 with site preparation. Trapping returns on ear-tagged animals are low because new sites are seldom trapped earlier than two years after their establishment. Up to February 1946, 12 beaver released without site preparation were retrapped, eight being taken at their original home colonies. Another was retrapped three miles from the point of release within a month; it had been badly injured by fighting. This would indicate that mixtures of strange animals is not desirable. The probable returns from the 84 tagged animals were materially reduced by disease during the winter of 1942–43. Only two of the beaver released where site preparation was made were retrapped. One was taken at the artifi-

cially prepared site two years and 9 months after release. The other was trapped two and one-half miles from the prepared site; it was driven away from the latter by dogs after living there one year (Table 1).

SITE PREPARATION AND PLANTING

A suitable site involves several essential features. The water supply must highways, farm lands, or domestic water supplies.

After a desirable planting site has been located, it is necessary to choose the place to build a house and dam. It must be remembered that beaver prefer to float their food downstream, hence the food supply should be above the dam site. A stretch of stream bed without too much drop and with sloping

TABLE 1.—BEAVER MOVEMENTS IN THE NORTHERN BLACK HILLS, SOUTH DAKOTA. (as revealed by recaptures of tagged animals)

Tag no.	Date released	Distance from original home, miles	Date retrapped	Distance from	
				Old home, miles	New home, miles
			NO SITE PREPARATION		
3[a]	5/23/42	8	6/25/42	5	3
7[a]	8/ 9/42	14	2/ 4/43	7	7
12[a]	6/ 8/42	6	4/15/44	0	6
54[a]	10/ 1/43	14	10/31/43	0	14
55[a,c]	10/ 1/43	14	10/31/43	0	14
88[a]	8/22/44	2	4/29/45	6	8
10[b]	6/ 8/42	7	12/30/43	0	7
29[b]	9/ 5/42	12	3/ /45	0	12
55[b,c]	10/31/43	30	5/ /44	0	30
58[b]	10/17/43	6	11/ /44	0	6
80[b]	8/15/44	10	12/ 5/44	10	2
85[b]	8/15/44	6	11/ /44	0	6
			NEW SITE PREPARED		
18	6/27/42	12	4/17/45	12	0
53[d]	8/10/43	14	3/27/45	11.5	2.5

[a] Released in same drainage where originally caught.
[b] Released over a divide in different drainage than where originally caught.
[c] Returned twice to original home, once down same drainage and once over a divide.
[d] Lived in prepared site one year, then driven out by dogs.

at least equal that which will flow freely through a one-inch pipe. There must be ample food consisting of aspen, willow, or other plant materials suitable for beaver. The headwaters of small streams usually supply these two needs, and at such locations the beavers often develop springs to increase the water supply. Precautions must be taken to avoid sites where flooding will constitute a nuisance to banks provides an ideal construction site. Mark the spot where the dam is to be built and make an estimate as to how far a small handmade dam will back the water. A line level or an abney level is useful in determining the desired height of the dam.

At a point approximately one-third the distance between the site for the dam and the greatest distance the water will be backed, a trench about 12

inches wide by 14 inches deep is dug from the creek bed up the slope of the bank for several feet. If possible, the mouth of the trench should be near a clump of brush, or a tree or stump. This additional cover at the entrance to the lodge seems to give the beaver greater sense of security. The trench must be so constructed that when the dam is built the impounded water will completely cover the entrance, and the upper end of the trench will be enough above the water level to allow the animals to build the temporary dam higher if they so desire. The upper end of the trench should be enlarged to a width of about three feet by 18 to 20 inches deep. This will provide a suitable temporary lodge compartment. The sod and the dirt taken from the trench and the house should be carefully set aside for use in recovering the structure. After the excavating is completed, the trench and house should be covered with old lumber or dead sticks cut to fit the width of the trench; this then is completely covered with sod and dirt. It is well to pile brush around and over the trench and house to form a barrier against livestock. Sticks that might be eaten by the beaver should be avoided in this construction. The dam is built next and the water backed up until it completely covers the entrance to the trench. Having the entrance to the lodge under water is essential and should never be neglected. A small spillway at one end of the dam and a small check dam below the main dam completes the construction. The small check dam gives the beaver additional swimming space and may temper their desire to tour. Under average conditions, two men can prepare a house and dam of this type in two to six hours. A few pieces of aspen or willow placed in the water at the head of the dam will provide food for a few days or until the beaver become established in the new surroundings. The beaver should be released near the opening of the trench and will usually enter the latter without hesitation. It is well to be sure they find the entrance to the new lodge. If they climb out of the water or start up or down the stream they should be herded back to the dam until they find the entrance to the trench. Within a couple of weeks, new improvements will have been made according to the beavers' idea of how a home should be built and the colony will be firmly established.

Stray beaver should never be used in a planting program. Care should be taken to plant together only members of the same family. A mixture of strange animals often results in fighting and in desertion of the colony. Transplanting in the late summer and early autumn is best, as this is the season when the animals normally repair their dams and lodges and store the winter food cache. The wandering urge is also least during that time of the year.

LIVE TRAPPING

Two types of live traps have been used in South Dakota. the Bailey and the Hancock (Pl. 22). The latter, a South Dakota product, is preferred in this area because it can be set in places where the Bailey type is not adaptable. Either trap, if properly used, will serve effectively in catching live beaver.

TRAPPING FOR PELTS

Between 1936 and 1945, a total of 1,892 beaver were trapped and pelted

from the 700 square miles constituting the Northern Black Hills. Of this number, state trapper wardens caught 1,372 and permit holders 520. Half of the permit holders' pelts were turned over to the State in accordance with regulations. The State therefore received the revenue from 1,632 pelts. Because the great majority of these animals were taken by state trappers, the work was done when the skins were most prime and good preparation was a requirement. These practices guarantee top prices on the fur market and give the State an opportunity to place use of the beaver on a sound management basis.

MANAGEMENT PRACTICES

The proper execution of this management policy hinges on a number of essential field practices. The warden must know his territory well and locate all existing colonies. During his travels he must be on the lookout for possible sites to establish new plantings. Each existing colony should be inspected at least once every two years. Colonies which appear to have a "full house" and a fast diminishing food supply should be scheduled for trapping. If there is a good site for a new colony within a reasonable distance, the excess animals should be live trapped and planted at the new location. If no planting is needed, the excess animals down to one pair should be removed and pelted during the winter.

The method practiced by the senior author is to carry a notebook with a typed form for listing recommended action on colonies as they are visited. These sheets cover a drainage basin (or portion of one) and each colony thereon is listed in order of its occurrence

TABLE 2.—TYPE OF FIELD NOTES USED FOR DETERMINING THE BEAVER HARVEST BY DRAINAGE.

BEAVER SURVEY
and
TRAP RECORD

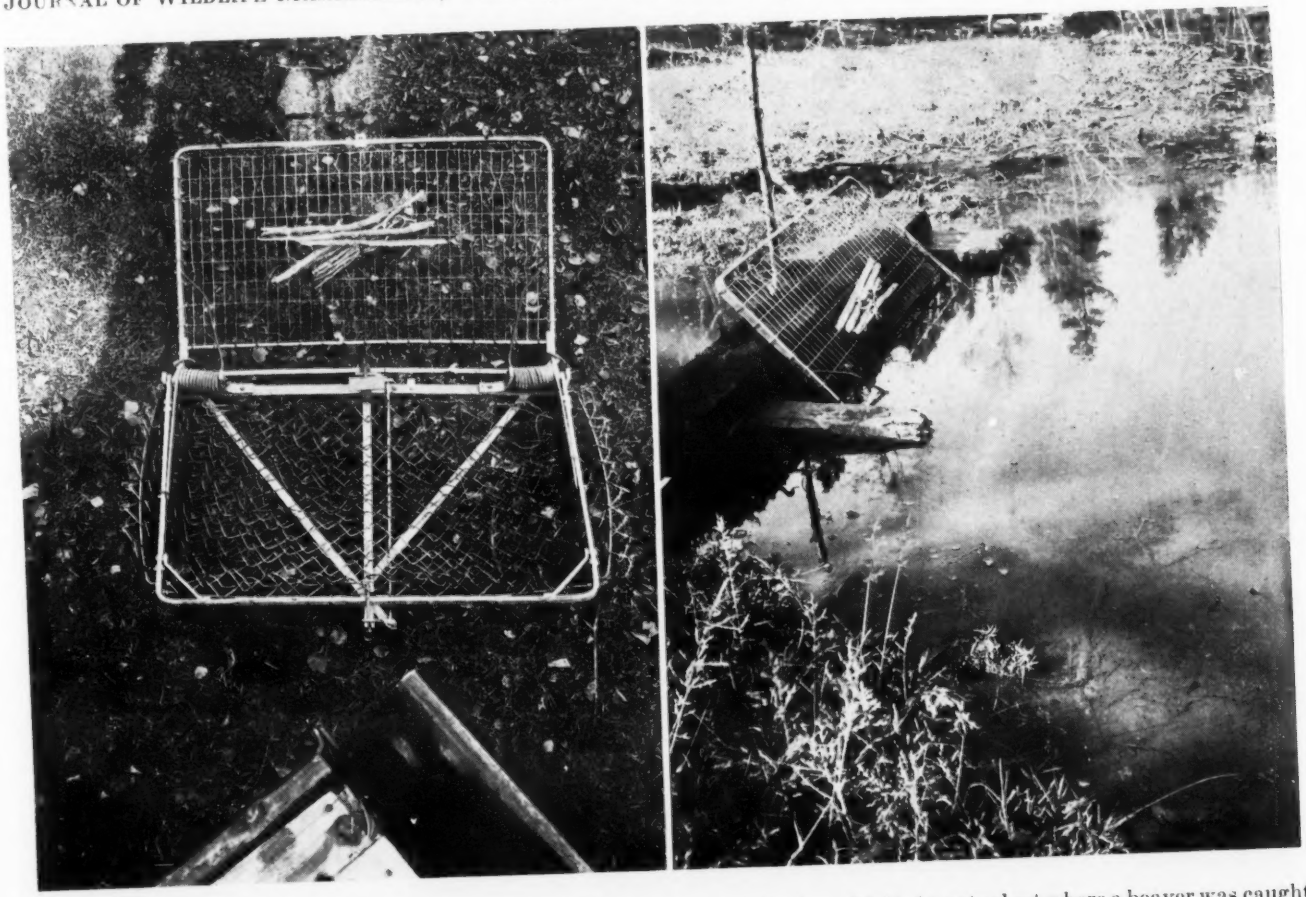
Date: October 19, 1944
Location: S. Fork of S. Boxelder near head; west of 85A
Observer: Harris and Aldous
Notes: Feed short on lower end, fair in upper end; many large dams

Number of caches	Estimated number of beaver	Beaver	
		Trapped	Remaining
1	6—take 4	4	2
1	6—take 4	4	2
1	6—take 4	4	2
1	5—take 3	4	0
1	6—take 4	3	2
1	8—take 6	6	2
	37—take 25	25	10

Trapper: Tucker
Date: November 15–20, 1944

(Table 2). The number of food caches at each colony is shown in Column 1. In Column 2 (estimated number of beaver) the number of animals believed to be present and the number recommended to be removed are shown. A copy of this sheet is then given to the trapper warden, who enters in Column 3 the number of animals he removed and in Column 4 the estimated number of beaver left in the colony. With such a record on file for each drainage, it is possible to keep a close check on the beaver and to manage them on a sustained yield basis.

The purpose of this program is to keep a minimum number of beaver, usually one pair to each colony. In so doing the food supply at each location will serve for the maximum length of time. This will hold the beaver and they



Hancock live beaver trap used in South Dakota. *Left.* Trap set to show mechanism. *Right.* An actual set where a beaver was caught.

in turn will keep the dam in repair, maintain a water conservation unit, a watering place for wildlife and stock, a fish pond, and a fur-producing factory —all in one operation. Unless some such type of management is maintained, the beaver population will fluctuate; the State then will be forced to open and close the season repeatedly and will be faced with all the evils of so-called sport trapping over which there is little control.

COLORED RODENT BAITS AND THEIR VALUE IN SAFEGUARDING BIRDS

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Wildlife Research Laboratory, U. S. Fish and Wildlife Service, Denver, Colorado

In 1943 a paper presented before the North American Wildlife Conference at Denver[1] reported experiments showing the aversion of birds to unnaturally colored foods. Reference also was made to earlier experiments and some current work indicating that rodents, considered essentially or actually color-blind, paid little or no attention to the color of food items. These divergent reactions of birds and rodents to color were the basis of a concept that if poisoned grain, exposed for the control of field rodents, could be dyed a hue having a strong deterrent reaction on birds, the latter could be safeguarded against accidental poisoning. On the other hand, control operations against rodents would not be handicapped.

That paper also stated that the "aversion by birds to unnaturally colored food items probably is not the same in intensity or character with all species. There is some indication that there may be differences in reaction between the sexes of the same species. There is also the likelihood that individual birds (like individual human beings) possess abnormal color vision and that their reaction would vary from the normal pattern. On the basis of work done . . . most pronounced aversion manifests itself with respect to foods dyed with colors near the center of the humanly visible spectrum, in the yellow and green sectors. . . .

"The aversion observed is not permanent and may be overcome by birds under the stress of hunger, yet under actual field conditions bird populations do not normally persist in areas where food is scarce. Also, properly exposed rodent baits are as a rule available to birds for a relatively short time before being taken by the rodents for which they were intended. In other words there is little chance for birds to be 'educated' to the harmlessness of color.

"There is much of a precise and statistical nature yet to be done before the reaction of birds to colored foods is fully understood."

Additional studies have since been carried on, and progress made in injecting the principle into operational practice. As so frequently happens, however, the exigencies of governmental work,

[1] Kalmbach, E. R. 1943. Birds, rodents and colored lethal baits. N. Amer. Wildl. Conf., Trans., **8**: 408–416.

with insistent demand that action programs follow as closely as possible the discovery of new facts, have delayed research "of a precise and statistical nature" so important in such a problem. With the war at an end, it is hoped that more attention can be given to some fundamental and underlying principles of color aversion by birds and the lack of this among mammals. The more important of these unknowns are mentioned at the end of this article.

A motion picture in Kodachrome, recently released by the U. S. Fish and Wildlife Service depicts the story of color aversion by birds and the lack of this response by small rodents. This film, "Birds, Beasts and the Rainbow," shows the very definite discrimination against unnaturally colored food by 11 species of birds and the acceptance of vari-colored grains by eight kinds of mammals. An introduction emphasizes the importance of color vision and a concluding section shows the practical application of the theme of the picture. The subject matter, arrangement, and photography are by E. R. Kalmbach.[2]

In the meantime a series of field experiments have been made under conditions that closely simulate those of rodent control operations. Because of their significance in showing what may actually take place in the field, it seems desirable to publish the preliminary results as a contribution to the subject. The birds involved were those present in the respective areas, and the extent of their feeding on the colored grains exposed was purely a matter of their own choice. The several experiments were not alike in design, but opportunity was afforded for birds to choose between two colors or between colored and uncolored grain. Determination of results were either by estimating the amount of grain of each type eaten or through the more drastic and realistic operational procedure of counting the number of dead birds that succumbed to colored and uncolored poisoned baits.

Experiments were conducted in a general farming area of Routt County, Colorado, where three kinds of blackbirds, English sparrows, magpies, and mourning doves were the dominant species most likely to feed on grain baits. A standard rolled-oat bait was used, conveying 1 ounce of strychnine to 14 quarts of grain. This was prepared as green, yellow[3] and uncolored bait and about one pound of grain was scattered at each "placement." This is not the procedure followed in field rodent control, when about one tablespoonful of grain is scattered about each burrow.

At six farms, uncolored, green, and yellow poisoned grains were exposed close to each other: at two, green alone was placed; at two others, yellow alone; and at the last two, only uncolored grain was placed. At the midpoint of the experiment, depleted supplies of grain were replenished and uncolored grain was added at the locations where previously only green or yellow grain had been exposed. Inspections were made on each of six days of exposure,

[2] When sufficient copies become available, this film may be obtained for showing on payment of transportation costs both ways from the U. S. Fish and Wildlife Service, Merchandise Mart, Chicago 54, Illinois.

[3] Dyes used: "Victoria green (W.B.) base" (Oil soluble) and "National Yellow, (S.P.)" (water soluble), National Aniline Division, Allied Chemical and Dye Corporation, San Francisco and New York.

and yielded the following data:

No dead birds were found on or about locations where green grain alone had been exposed, and only two where yellow grain had been placed; but 66 were picked up where there had been opportunity to feed on uncolored grain. Examination of the stomachs of 56 of the poisoned birds disclosed no green grain; yellow was found in 5 (9%); uncolored grain in 43 (77%); and in 8 stomachs (14%) digestion had progressed too far to disclose the character of the grain eaten. The birds poisoned were 39 Brewer blackbirds, 11 redwinged blackbirds, 2 yellow-headed blackbirds (immature), 6 English sparrows, 6 magpies, and 2 mourning doves.

Later (August 16–21, 1945), when birds generally were more granivorous, a similar experiment was conducted in the same area. Again a thorough search was made for birds that had succumbed to the various kinds of poisoned baits, and 79 were found dead; 8 redwinged, 51 Brewer, and 1 (immature) yellow-headed blackbirds, along with 6 mourning doves, 1 magpie, 1 crow, 10 English sparrows, and 1 (young) mallard. Stomach examination showed that 68 had fed on uncolored grain and 2 on yellow-dyed grain; in 9 others, digestion had destroyed any evidence of color. In none was green grain seen. These were the results, although uncolored, yellow, and green grains were equally available.

Another series of experiments was made in Day County, South Dakota, during May 1945. In 1938 Welch had carried on trials there for the control of the Richardson ground squirrel; because of this earlier experience, the locality was known to be one in which danger of killing birds was great. It is a "pot-hole" country with many ponds and small lakes amid extensive grain fields, supporting an abundance of grackles, redwinged and yellow-headed blackbirds, cowbirds, meadowlarks, mourning doves, horned larks, and the ubiquitous English sparrows. Although less abundant than seven years earlier, colonies of Richardson ground squirrel occupied areas also used by one or more of these ground-feeding birds.

Throughout this region it has long been the practice of individual farmers to expose poisoned baits for ground squirrel control. Even with the best of instructions and care, squirrel control under the conditions prevailing there presented a hazard for bird life. Hence the area was chosen to determine the protective value of color on baits.

In all, 11 separate experiments were carried out in Day County. In three, non-poisoned grain was exposed and note taken of the degree of acceptance of colored and uncolored portions; in the other eight, poisoned grain was exposed for the dual purpose of controlling squirrels and observing the extent of bird mortality.

The results in the three experiments using non-poisoned grain were as follows. In the presence of a mixed population of birds dominated by grackles, redwinged blackbirds, starlings, mourning doves and domestic ducks and geese, the equal exposure of uncolored, yellow, and green grain in small piles for 24 hours disclosed that 88, 73, and 23 per cent, respectively, had been eaten. When only yellow and green grains were exposed similarly, 87 per cent of the yellow and 39 per cent of the green were removed. In a duplicate of the last experiment at another place where red-

winged and yellow-headed blackbirds, grackles, mourning doves, and a few pheasants were present, 15 per cent of the yellow and 9 per cent of the green-colored grain were removed.

Small nocturnal rodents may have removed part of the grain, and exposure of bait in small piles is not the practice in rodent control; these conditions lessened the merit of the results. Of greater import and validity were the results from experiments in which poisoned grain was exposed in approved rodent control manner, and the results measured by the number of dead birds retrieved from the plots baited with colored and uncolored grain.

To avoid repeating details for each of the experiments, two which typify the procedures used, will be explained and then information for the whole group summarized (Table 1).

In one experiment (Nos. 2 and 2* of Table 1) the initial exposure consisted of six pounds each of uncolored, yellow, and green rolled oats. This was scattered at squirrel burrows and about cattle droppings in three separate sections of a used pasture. The bait placements were below average in size, approximating 100 to the pound. An additional pound each of uncolored and green grain was placed in small piles along an adjacent roadway; thus the quantities of poisoned grain exposed were 7 pounds of green, 7 pounds of yellow, and 6 pounds of uncolored. No attempt was made to search wide areas surrounding the plots for affected birds. Limitations in time and man-power restricted inspection to the plots and narrow strips surrounding them. By noon of the third day after exposure, the following dead birds had been recovered

TABLE 1.—AMOUNTS OF POISONED BAIT EXPOSED AND NUMBERS OF DEAD BIRDS FOUND ON EACH OF 8 EXPERIMENTS. IN 4 EXPERIMENTS *(marked with asterisks)* UNCOLORED POISONED GRAIN WAS SUPERIMPOSED ON COLORED GRAIN AFTER THE LATTER HAD BEEN EXPOSED FOR SEVERAL DAYS. IN SUCH CASES THE INCREASED MORTALITY THAT FOLLOWED IMMEDIATELY MAY BE CHARGED LARGELY OR ENTIRELY TO THE UNCOLORED GRAIN.

Experiment number	Area containing uncolored grain		Area containing yellow-dyed grain		Area containing green-dyed grain	
	Pounds of bait	Dead birds	Pounds of bait	Dead birds	Pounds of bait	Dead birds
2	7	14	6	2	7	0
2*	12*	46*				
3	2	5	2	2	2	0
3*	4*	6*				
4	5	5	4	0		
4*	4*	0*				
6	8	0	8	1	6	0
6*	14*	6*				
9	8	0	9	0	4	0
10			7	2		
11	5	4	3	2		
12	8	0	6.5	0		
Totals:						
Initial experiments 43		28	45.5	9	19	0
Uncolored overlay 34*		57*				
Combined mortality 77		85	45.5	9	19	0

from the three plots:

	Uncolored grain	*Yellow grain*	*Green grain*
Yellow-headed blackbird	6	2	0
Redwinged blackbird	3	0	0
Meadowlark	3	0	0
Grackle	2	0	0
Totals	14	2	0

When these losses were computed against the quantities of grain exposed, the uncolored was charged with killing 2 birds per pound of bait, the yellow with ½ bird per pound, and the green with none.

Then it was decided to "overlay" the green and yellow bait areas with uncolored bait to demonstrate whether birds actually were feeding in these two sectors to the same degree as in areas containing uncolored bait. Consequently 6 pounds of uncolored bait of the same toxicity as the colored was exposed on both the "yellow" and "green" areas; records again were taken of the birds picked up there, as well as on the area of uncolored grain to which no additional bait had been added. The results after three more days of exposure were:

	Uncolored grain, original lot	*Uncolored over yellow*	*Uncolored over green*
Yellow-headed blackbird	8	11	10
Redwinged blackbird	7	0	5
Meadowlark	1	1	1
Horned lark	1	0	0
Totals	17	12	16

It is quite evident from the sudden increase of mortality on the "yellow" and "green" plots immediately after they had been overlain with uncolored bait, that the latter was largely and probably entirely to blame. This was corroborated by stomach analysis of 60 of the 62 birds picked up throughout the experiment. Uncolored oats were found in 42, yellow-dyed grain in 2, and green in none. In 2 additional stomachs the evidence was questionable, and in 14 digestion had eliminated all evidence of the birds having fed on oats.

In another experiment of similar design (Nos. 3 and 3*, Table 1) two pounds each of the uncolored, yellow, and green baits were exposed on areas of pasture land adjacent to a small pond, in the presence of a limited bird population. The placements made at squirrel burrows conformed in number and size with procedures commonly used in control of the Richardson ground squirrel. During 4 days of exposure, the following birds were found dead on or immediately adjacent to the respective plots:

	Uncolored grain	*Yellow grain*	*Green grain*
Yellow-headed blackbird	3	1	0
Redwinged blackbird	1	0	0
Meadowlark	1	1	0
Totals	5	2	0

At this stage the mortality was 2.5 birds per pound of uncolored bait, 1.0 per pound of yellow bait, and none for the green-dyed grain.

Again, the areas on which yellow and green baits had been exposed were overlain with uncolored poisoned grain of the same toxicity, two pounds each of yellow and green being distributed as in normal bait exposure practice. Five days later the following dead birds were found on the three areas (then all containing uncolored bait):

	Uncolored, original lot	*Uncolored over yellow*	*Uncolored over green*
Redwinged blackbird	1	2	0
Yellow-headed blackbird	0	0	1
Cowbird	0	1	0
Grackle	0	0	1
Totals	1	3	2

Although the bird population was not dense and more nearly average, the aversion to color was as in the previous experiment. This was corroborated by stomach analyses of 10 of the 13 birds found dead throughout the experiment. Six contained uncolored grain, 2 yellow, and none green. In one other stomach the evidence was questionable and in another no oats was detected.

The combined results of these 8 experiments show that 28 birds were killed by 43 pounds of uncolored bait (0.65 per pound) when exposed in plots adjacent to others containing yellow and/or green-dyed baits. At the same time, 9 birds were killed by the exposure of 45.5 pounds of yellow-dyed bait (0.2 bird per pound). So far as could be determined, no birds were killed on areas where green-dyed bait was exposed.

When some plots containing colored grain (marked * in Table 1) were overlaid with uncolored grain after several days of initial exposure, there was an immediate increase in mortality. Some of this mortality may be attributed to continued acceptance of limited quantities of yellow grain, but subsequent stomach analyses of the victims indicated that the uncolored grain was responsible. Upon this assumption, 77 pounds of uncolored grain accounted for the killing of 85 birds (1.1 birds per pound of bait).

It must be emphasized that the dead birds recorded were only those found on or immediately adjacent to the poisoned plots. Others doubtless would have been found by more extensive search. Furthermore, birds definitely affected by strychnine yet able to fly away from the plots, were not included.

The overall picture of color aversion as shown by examination of 90 stomachs from birds found dead in these experiments in South Dakota shows that 61 (68%) had eaten uncolored grain, 7 (8%) had taken yellow grain, and none had fed on the green. In 17 stomachs (18%) digestion had removed evidence of oats having been eaten, and in 5 (6%) the identification of color was questionable.

Observations by R. W. Enderlin in a study of valley quail in the Kettleman Hills, California,[4] and reported to us in correspondence from Ben Glading, seem worth mentioning in this compilation of recent notes on the reaction of birds to color. With certain unimportant omissions and editorial changes, Enderlin's comments were as follows: "Valley quail seemed to display a definite avoidance to the brightly colored grain. Often in alighting they seemed to soar or coast over the spots. In walking, more often than not, they would go around the spots where the color was most dense.

"On one occasion Mr. Miller saw a mourning dove take a few colored kernels. . . . The small passerines, especially the crowned sparrows, seemed to display an avoidance reaction.

[4] Glading, Ben, R. W. Enderlin, and Henry A. Hjersman. The Kettleman Hills quail project. Calif. Fish and Game, 31: 139–156, 1945.

"Cottontails, jack rabbits and ground squirrels were seen to feed upon it with great gusto."

As stated earlier, many aspects of the reaction of birds and mammals to colored food remain to be determined. The following are matters for which answers must be had before the fullest and most effective use can be made of color to prevent birds from feeding on poisoned rodent baits.

This matter involves not only the reaction of birds and mammals to color, but also the aversion of birds to certain discernible hues; hence a thorough review of all experimental work on color perception among birds and mammals is in order, after which pertinent experimental work may be outlined to supply the most needed missing information.

Hues of optimum deterring effectiveness must be determined for the species most in need of protection. Some experimentation can be done under control in cages, but the ultimate effectiveness will need to be determined in the field where colored and uncolored toxic baits may be compared as to their destructiveness for wild birds feeding under conditions existing in the control of field rodents.

Information is needed on the extent of aberrant color vision among wild birds; a high degree of abnormal color vision would tend to lower the general effectiveness of this procedure. There is some evidence of differences in reaction to color by the two sexes of a species; if true, emphasis should be placed on determining the color most deterring for the females.

There is also the matter of technique in applying dyes effectively to grain baits. The color should be reasonably fast and economical to apply, and should not lower the acceptance by rodents in any appreciable degree because of objectionable taste or odor.

What appears to be purely a chemical problem has arisen in the color-destroying action of strychnine on many green aniline dyes. This fact, and an adverse taste factor (to rodents) produced in combining green dyes with thallium has compelled the use of a brilliant yellow considered the second most effective color in deterring birds. The latter dye, not noticably objectionable to rodents, is now being applied to all grain baits prepared by the U. S. Fish and Wildlife Service with a new rodenticide ("1080") for field exposure.

Present evidence points to the central portion of the humanly visible spectrum as having the most deterring effect on grain-eating birds, but it remains to be determined whether this is due wholly to particular wave lengths. If sheer luminosity plays an appreciable part, some luminous (metallic) pigments may have value as deterrents.

There is the likelihood that, because of the chemical or dye-destroying properties of some poisons, as well as the disturbing taste factors created by certain combinations, the solution of this problem may rest in a series of formulas involving different but compatible poisons and dyes to meet the various situations.

The existing unknowns are a most inviting challenge. The reward for a practical solution is of the highest order: it will be a realization that wildlife management has progressed a step forward, and that reductional control, when necessary, can be made more

selective than formerly was possible.

In the realm of the theoretical, there is reason to believe that, in the development of effective deterrent colors, new and clarifying evidence will be shed on the manner in which birds respond to "warning coloration," a discussion that waxed warm about thirty years ago.

NEWS NOTES

With completion of the October 1946 issue of THE JOURNAL OF WILDLIFE MANAGEMENT, Dr. Tracy I. Storer has resigned as Editor. Dr. Harlow B. Mills, Department of Zoology and Entomology, Montana State College, Bozeman, Montana has been appointed as Editor by the Council. Dr. Mills will assume his duties with preparation of the January 1947 issue. All manuscripts for publication, books and papers for review, and correspondence about them henceforth should be addressed to Dr. Mills.

Funds have been made available to The Arctic Institute of North America by which it is possible to offer two Fellowships of up to $2,000 each (Canadian currency) for scientific work in the Canadian Arctic or Subarctic during 1947. The Fellowships are open to anyone who has demonstrated his ability to carry out research work of superior quality in some field of science. Applications must be received by November 1, 1946. Fellowships will be awarded on the recommendation of the Board of Governors of the Arctic Institute, and will be announced by February, 1947. Fellowship application forms may be obtained upon application to: The Arctic Institute of North America, 805 Sherbrooke Street West, Montreal, Canada.

The previously announced 1946 Fellowships of $1,500 each were awarded to Dr. Margaret Lantis of Washington, D. C., for ethnologic study of the Eskimos on Nunivak Island, Alaska, and to Mr. Harold C. Hanson, a member of the Wildlife Society and Assistant Game Technician of the Illinois State Natural History Survey, for research on the breeding habits of Canada Geese on the west coast of James Bay, northern Ontario. An additional grant was made to Dr. Nicholas Polunin of Oxford University, England, for botanical work on Ungava Peninsula.

Constitution and By-Laws of The Wildlife Society[1]

CONSTITUTION

ARTICLE I—Name

The name of this Society shall be The Wildlife Society.

ARTICLE II—Objectives

The principal objectives of the Society shall be: (1) Establishment of professional solidarity and the maintenance of the highest possible professional standards; (2) development of all types of wildlife management along sound biological lines; (3) publications to effect these ends; and (4) protection of the interests of its members.

ARTICLE III—Membership

Sec. 1. The membership of this Society shall consist of Active Members, Associate Members, Life Members, and Honorary Members.

Sec. 2. Active Members shall be persons professionally engaged in the practice or teaching of wildlife management, in wildlife administration, in wildlife research, or in graduate study of these subjects, who are graduates of a school approved by the Council, or who, in the opinion of the Council, have acquired an understanding of wildlife management principles and techniques comparable with that required by a school approved by the Council.

Sec. 3. Qualifications of applicants for active membership shall be passed upon by a standing committee of five members who shall be nominated by the Council and elected by the Society at its annual meeting; three members of the committee to be elected in odd numbered years, two members in even numbered years, to hold office for two years each. Election of applicants for active membership shall be made by the Council from among those recommended by the Membership Committee.

Sec. 4. Any person may become an Associate Member upon recommendation of two Active Members and acceptance by the Secretary.

Sec. 5. Honorary Members shall be persons who, upon a two-thirds vote of the Council and a two-thirds vote at any stated annual meeting of the Society, are thus recognized for their distinguished service or outstanding achievement in the field of wildlife management.

Sec. 6. Active Members shall be entitled to vote, to hold office, and to represent the Society officially. Life Members and Honorary Members who have been elected also as Active Members by the Council shall have such rights and privileges. All classes of members shall receive The Journal and such other publications of the Society as the Council may direct.

Sec. 7. Any Active or Associate Member may become a Life Member by paying the sum of $100.00 at one time into the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

ARTICLE IV—Officers

Sec. 1. The officers of the Society shall be a President, a Vice-President, a Secretary, and a Treasurer.

Sec. 2. The officers shall be elected annually by mail ballot except as noted below. The President and Vice-President shall serve until May 1 of the calendar year following their election and shall not succeed themselves. The Secretary shall be elected in each odd-numbered year and shall serve until May 1 of the next odd-numbered year. The Treasurer shall be elected in each even-numbered year and shall serve until May 1 of the next even-numbered year. Within 60 days of assuming office the President shall appoint a Nominating Committee of five members. Before November 1 of that year the Nominating Committee shall submit to the Secretary two available Active Members as nominees for each office to be vacated. The Committee's nominations shall be published in the next

[1] Including revisions as of May 10, 1946. See previous constitution, Journ. Wildl. Mgt., 7: 340–342. 1943.

January issue of The Journal of Wildlife Management or Wildlife Newsletter. Within 30 days of the date of mailing of this issue the names of additional available nominees for any office to be vacated may be submitted by any voting member in good standing and any nomination will be valid if submitted by 5 per cent of the voting membership. The Secretary shall then mail an election ballot bearing the Committee's nominations and those made by the membership as herein provided. Thirty days shall be allowed for the election ballots to be returned to the Secretary. The nominee receiving the largest vote for each office shall be declared elected. In case of a tie, the decision shall be made by a majority of the Council. The out-going President shall appoint a three-member committee within thirty days after the election to audit the nomination and election ballots. The auditor's report on balloting shall be published in The Journal of Wildlife Management or Wildlife Newsletter.

Sec. 3. The President shall preside at meetings of the Society, shall be Chairman of the Council, shall appoint all Committees, except the Membership Committee, including those established by the Council, and perform other duties incident to his office.

Sec. 4. In the absence of the President or in his inability to act, his duties shall be assumed by the Vice-President. In the event neither one can serve, the Council shall appoint a President pro tempore.

Sec. 5. The Secretary shall be the Executive Officer of the Society under the general direction of the Council. He shall issue notices of annual or special meetings of the Society. A report covering his activities during the preceding year shall be made by him to the Society at its annual meeting.

Sec. 6. The Treasurer shall be responsible for all funds of the Society except permanent funds held in trust and shall be bonded in suitable amounts as decided by the Council and at the Society's expense. His accounts shall be audited at the close of each year as directed by the President before presentation at the annual meeting of the Society.

Sec. 7. Vacancies among the officers shall be filled by vote of the Council from among the Active Members for the unexpired term of the office.

ARTICLE V—COUNCIL

Sec. 1. The Society shall be governed by a Council composed of the President, Vice-President, Secretary, Treasurer, and at least one representative from each of the Regions as defined in the By-laws. The Regional Representatives shall be elected annually, shall be eligible for re-election and shall take office on May 1 following their election.

Sec. 2. The Council shall appoint the Editor; shall have power to fill vacancies occurring in its numbers; shall recommend to the Society for action By-laws not inconsistent with this Constitution and shall perform such other duties as are herein prescribed. Not less than one-half of the Members of the Council shall constitute a quorum.

ARTICLE VI—MEETINGS

Sec. 1. The Society shall hold an annual meeting and such other meetings as the Council may direct at places and dates selected by them. Due notice of such meetings shall be given by the Secretary at least thirty days in advance.

Sec. 2. Resolutions passed at a meeting of the Society by less than a majority of its Active Members shall represent the majority opinion of the meeting, but shall not be binding on the Society unless subsequently approved by the Council.

ARTICLE VII—SECTIONS

Sections of the Society may be authorized by the Council upon petition of ten or more Active Members. Sections may adopt necessary By-laws, providing that no part of them shall conflict with the Constitution of this Society. A report of its activities shall be presented by each section at the annual meeting of the Society.

ARTICLE VIII—DUES AND FUNDS

Sec. 1. The annual dues of Active Members shall be $5.00 and of Associate Members, $4.00. Subscriptions shall be $4.00. No dues shall be charged Honorary Members.

Sec. 2. Annual dues shall be payable from January 1 in advance. Members in arrears shall forfeit their rights and privileges and shall receive no publications until such dues are paid.

Sec. 3. All monies accruing to the Society received for undesignated purposes shall constitute the Permanent Trust Fund, the proceeds from which shall be utilized to carry forward the work of the Society as directed by a three-fourths vote of the Council. In the absence of such direction, this income shall be reinvested by the Trustees.

Sec. 4. Bequests, grants or trusts made for the purpose of advancing the field of wildlife management and/or The Wildlife Society may be accepted by the Society, providing the Council shall have first favorably considered the objects and specifications set up by the trust. These shall be placed in the Permanent Fund.

Sec. 5. The Permanent Trust Fund of the Society shall be controlled in trust by a board of three Trustees with power to sell and reinvest according to their judgment. One Trustee shall be elected at each annual stated meeting for a term of three years. In case of vacancies caused by suspension, resignation or death, successors may be appointed by the Council for the remainder of the term. The Trustees shall be bonded in suitable amounts as directed by the Council and at the Society's expense.

ARTICLE IX—AMENDMENTS

The Constitution may be amended by a two-thirds vote of the Active Members of the Society, replying by ballot to a notice of the proposed amendment. Such notice must be submitted to all voting Members at least thirty days previous to the closing date for the receipt of ballots. Amendments may be referred to the Society for action either by a two-thirds vote of the voting Members at any stated annual meeting, or by a favorable vote of at least two-thirds of the Council.

BY-LAWS

I. ELECTION OF OFFICERS

Election of officers shall be made by mail ballot as specified by the Constitution.

II. ELECTION OF COUNCIL

Representatives to the Council shall be chosen, one from each of the following Regions:

Region 1: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, and West Virginia.

Region 2: Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Puerto Rico, and Virgin Islands.

Region 3: Ohio, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Illinois, and Indiana.

Region 4: North Dakota, South Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas.

Region 5: Arizona, New Mexico, Texas, Oklahoma, and Mexico.

Region 6: Washington, Oregon, California, Idaho, Nevada, Utah, Alaska, and Hawaii.

Region 7: Canada.

Additional Regions may be established for similar representation upon approval by the Council. Representatives to the Council shall be elected in each Region by any plan acceptable to the Council.

III. ORDER OF BUSINESS

The order of business at the annual stated meeting, unless changed by a two-thirds vote of the Active Members present, shall be as follows:

1. Reading and approval of the minutes of the previous meeting.
2. Report of the Secretary.
3. Report of the Treasurer.
4. Report of Regional Representatives and Sections.
5. Appointment of temporary committees.
6. Report and recommendations by the Council.
7. Action on business reported by the Council.
8. Reports of committees.
9. New and unfinished business.

IV. DELINQUENTS

A member shall be dropped from the annual list of members after becoming one year in arrears of dues. A member shall be reinstated upon payment of dues for the current year in which application is made. Any member serving in the Armed Forces of World War II may obtain back numbers of The Journal of Wildlife Management for the time he was in arrears because of the war at regular subscription prices. All other delinquents shall pay current prices for back numbers.

V. FISCAL YEAR

The fiscal year of the Society shall end December 31.

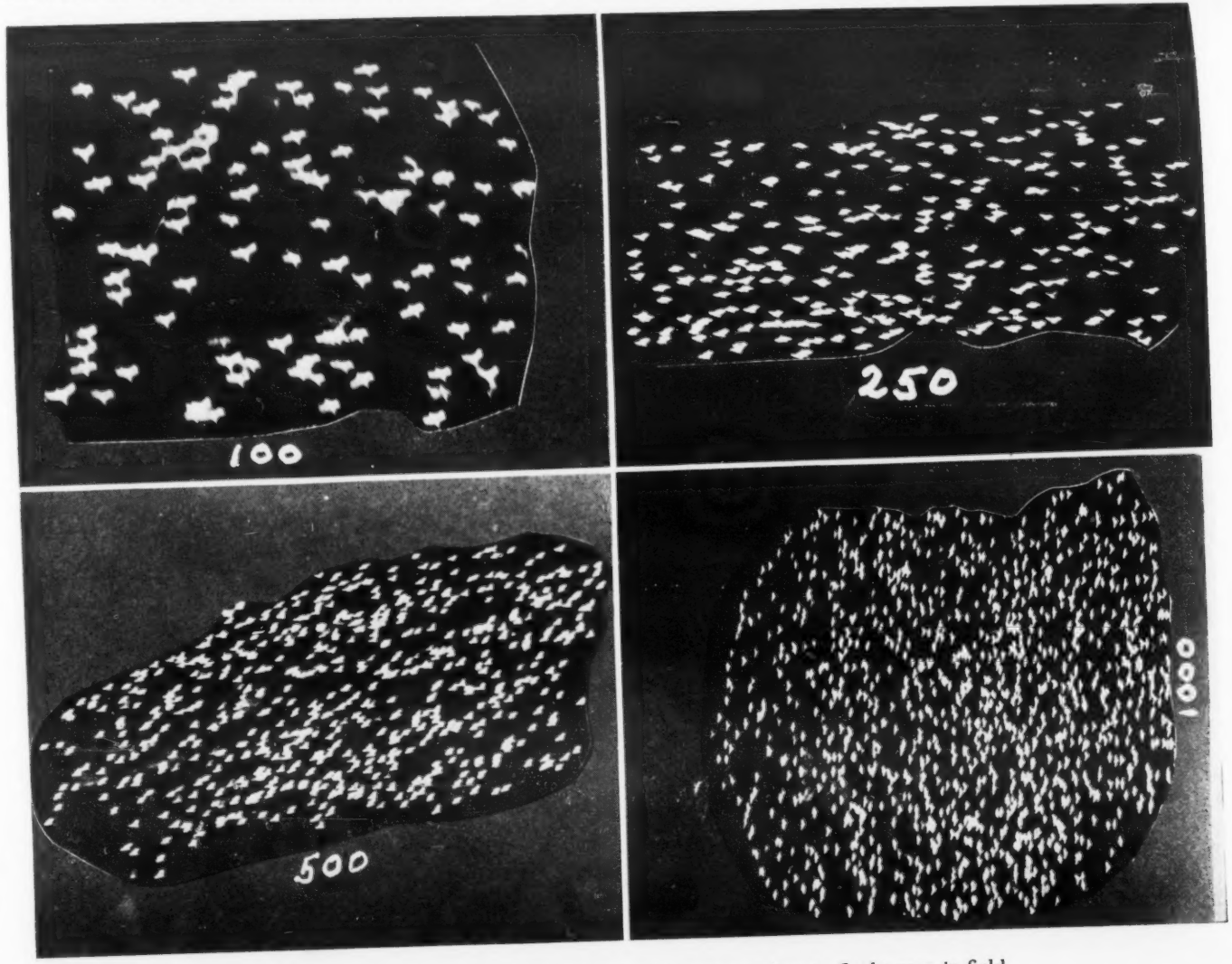
VI. EDITOR

The Editor shall be appointed by the Council. He shall serve for one year, or until his successor is appointed, and shall be responsible for all matters relating to the publications of the Society, subject to such restrictions as may be imposed by the Council.

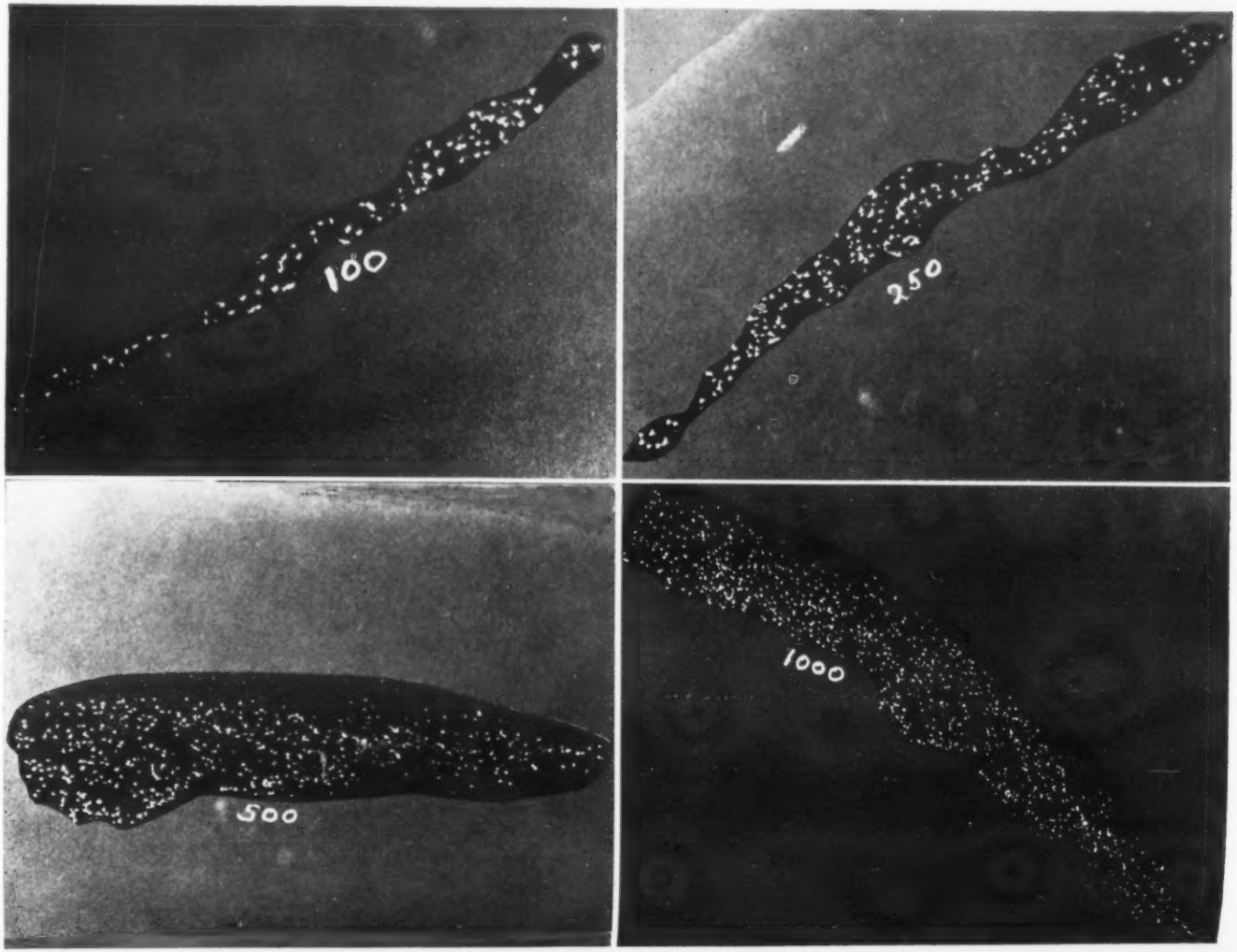
VII. BY-LAWS

By-laws may be adopted, amended or repealed at any annual meeting by a majority vote of the Active Members present.

PLATE 23
JOURNAL OF WILDLIFE MANAGEMENT, VOL. 10, NO. 4, OCTOBER 1946



Atlantic snow geese. Photographs used to estimate numbers in flocks seen in field.



Atlantic snow geese. Photographs used to estimate numbers in flocks seen in field.

BRIEFER ARTICLES

IMPROVED METHOD FOR ESTIMATING NUMBERS OF WATERFOWL

Extensive surveys of the waterfowl populations using the Bombay Hook National Wildlife Refuge were made during the spring and autumn migration periods of 1945. Numerical counts by species were made on foot, and from boats, cars, and airplanes. Eleven survey flights were made by the courtesy of Colonel Donald B. Diehl, Commanding Officer, 4146 Army Air Forces Base Unit, ATSC. An Army type L-1 airplane was used, which, when the landing flaps were lowered, reduced the air speed between to 45 and 50 miles per hour for the counting.

The census method commonly used for waterfowl in flight is to count the birds in a small segment of the flock and then estimate the number of times the segment will go into the entire flock to arrive at the total. This method was satisfactory on the surveys during the early and late phases of the migration, when flocks were small and few in number. It was unsatisfactory, however, during the height of the migration period when the flocks were large or when several were in the air at the same time. This method could not be used readily from an airplane because of the time necessary to count a segment and the tendency of flocks to move away from the plane. In many cases the method which had to be used was to compare the size of a flock with that of other flocks noted on previous flights. The "segment" method does not give satisfactory results with a large flock—only a small fraction can be counted, usually 50 to 100, and such a segment is too small to have much value in estimating the numbers in a large flock. Furthermore large flocks tended to change form in the air to such an extent that in some instances part of the flock was counted twice and others not at all.

It was felt that if a means of rapidly estimating the numbers in small flocks could be combined with one for obtaining more accurate estimates of large flocks, the resulting observations would have greater value.

The opportunity to develop such a method was realized when a flock of Atlantic snow geese was photographed at the Refuge on November 29, 1945. Six pictures were made by Master Sergeant Robert Livingston from an airplane piloted by Captain Lyall Fraser. The best two pictures were enlarged to 20×24 inches and the geese then counted individually. The total was 2,659, including 11 blue geese. The enlargements were cut down to include flocks of known size and copied on 4 by 5 inch prints (Pls. 23, 24). Two pictures of each sized flock were made, a group and a long string, as these are the basic flying formations of the waterfowl. The presumed error is estimated to be from 1 to 3 per cent due to overlapping of birds and other factors.

For field use, such pictures were attached to stiff 4×7-inch cardboards, using scotch tape or similar material; glue or staples were unsatisfactory. Then an observed flock was compared with the photographs to determine the approximate size of the flock. In some cases two or more of the photographs were used to arrive at an estimate of the flock size. The advantages of this method are that small flocks may be estimated readily by comparison, and for large flocks the photographs serve as an accurately-counted segment for determining the size of the flock. A more accurate estimate can thus be made because a larger segment is used than would ordinarily be counted.

Acknowledgment is made to Major Jewell C. Cann, Mr. Clifford V. Hagerman, and Sergeant George Bauss of the Photographic Section, 4146 Base Unit, ATSC, who assisted materially in completing this work.—GEORGE P. SPINNER, *Bombay Hook National Wildlife Refuge, Smyrna, Delaware.*

Atlantic snow geese. Photographs used to estimate numbers in flocks seen in field.

CONSERVATION OF MEGAPODS BY SOLOMON ISLAND NATIVES[1]

I was stationed in the South Pacific on New Caledonia during part of my tour of duty with the Army, and while there also had opportunity to visit seven islands of the Solomon Island Group. While visiting Savo Island an instance of wildlife conservation by the natives came to my attention. I was much impressed, as it was the only definite attempt at such conservation or management by any of the natives I came in contact with in the South Pacific.

Savo Island is small, rising abruptly from the sea. It is volcanic, rough, and heavily vegetated, and supports a small native population along one shore. Because of the rough and steep terrain, garden land is at a premium. The surrounding waters are infested with man-eating sharks, and fishing is not as extensive as off other islands. Because of these circumstances, the natives depend upon eggs of the bush turkey or megapod (*Megapodius freycinet eremita*) as a diet supplement.

The natives allow megapod hunting only during two months of the year, and then the birds can be killed only in the "bush." Since the megapods rarely get far from the beach, few are actually taken. It was not determined just which two months are open to hunting. Megapods are hunted and killed on the other Solomon Islands at any time or season. The Savo Islanders also actually manage these birds. Each native family is allotted a certain amount of the beach on which the megapods lay their eggs. It was not ascertained how the plots were acquired originally, but now the plots are handed down through the generations by the family head. Each family is entitled to the eggs laid on its respective plot. To perpetuate the seed stock, a certain percentage of the eggs are left to hatch; but the percentage and the method of control over this were not determined. To encourage megapods to lay in their particular plot, members of a family watch the plot and when they see a megapod scratching around preparatory to laying, a member of that family clears away any brush or foreign matter that may be in the bird's way. In the Solomon Islands, the megapod lays its eggs in sand at a depth of two and a half to three feet, consequently either the egg has to be dug up immediately or the laying site must be marked.

Thus the Savo Island natives, to supplement an otherwise scanty diet, protect and manage the megapod for its eggs. This is the only instance of native effort at conservation noted on eight South Pacific Islands.—A. J. NICHOLSON, *Texas Game, Fish and Oyster Commission, Austin, Texas.*

[1] Data obtained while attached to U. S. Navy Historical Survey Unit; article approved for publication by Office of Public Information, U. S. Navy.

USE OF OAKS BY BEAVERS IN NEW HAMPSHIRE

During investigation of a beaver flowage in the Pawtuckaway region of southern New Hampshire, observations were made on cutting and use of oak by beaver. Previous mention of such use has been made by Bradt (Journ. Mammalogy, 19: 139–162, 1938) of scrub oak in Michigan and by MacNamara (Journ. Mammalogy, 10: 255–256, 1929) of scrub and red oaks in Ontario.

In the area investigated, many white and red oaks (*Quercus alba* and *Q. rubra*) up to 10 inches in diameter had been felled. Trees up to four inches in diameter at the cut had been removed entirely, but whether used for food as well as for building and damming material could not be determined. Of the felled trees remaining, only one showed any sign of use for food, although the tops of some reached almost to the pond's edge. This tree, a red oak five inches in diameter at the cut, had been sectioned, and two pieces, 12 and 36 inches long, respectively, were left. These sections had been completely peeled and there were no traces of the bark so it was assumed that at least this part of the tree had been used for food.

The largest trees attacked by the beavers were a 15-inch red oak and a 21-inch white

oak. The red oak had been completely and deeply girdled but not felled, and the white oak half girdled to a depth of about two inches into the wood.

The reason for the cutting could not have been food, since species such as speckled alder, gray birch, willows, and red maple, and various aquatic plants, are abundant in the area. —WILLIAM J. JAHODA, *Biological Institute, University of New Hampshire, Durham, N. H.*

ANTELOPE FOODS IN SOUTHEASTERN MONTANA

Stomach samples from 24 prong-horned antelope (*Antilocapra americana*) in Carter County, Montana, were collected during the hunting seasons of 1944 and 1945, mainly during September and October; a few were obtained in November and December. Information is needed to determine the food habits of antelope, about which there is considerable controversy.

Each sample consisted of a pint of stomach contents; this was partly washed in a piece of burlap to get rid of the stomach juices, and then dried in paper envelopes. The foods were classified and visual estimates made as to volume on a percentage basis (Table 1).

TABLE 1.—AUTUMN FOODS OF PRONGHORNED ANTELOPE IN MONTANA.

Species	*Frequency*	*Percentage*
Sage (*Artemisia*)	22	*51.0*
Snakeweed (*Guterriezia*)	7	*14.3*
Snowberry (*Symphoricarpos*)	14	*10.3*
Salt sage (*Atriplex*)	5	*1.0*
Greasewood (*Sarcobatus*)	1	*0.8*
Cactus (*Opuntia*)	7	*4.2*
Miscellaneous browse	6	*5.7*
Total browse, percentage		*87.4*
Vetch (*Astragalus*)	3	*0.4*
Miscellaneous weeds	17	*5.3*
Total weeds, percentage		*5.7*
Grass	21	*6.7*
Grass, percentage		*6.9*

The principal food of these animals during the autumn obviously consisted of browse plants, based both on the volume and the incidence of occurrence in the diet. The most preferred plant was sage (*Artemisia tridentata* and *A. cana*) of which leaves and twigs were eaten; several samples were almost entirely of sage. Snowberry or buckbrush (*Symphoricarpos*) was next, twigs, leaves, and berries having been used. Snakeweed or matchweed (*Guterriezia*) was third in importance, and several samples consisted almost entirely of this plant. There was a question as to whether considerable rabbit brush (*Chrysothamnus*) was included here, as this food has been reported from antelope in Colorado and South Dakota. These two plants are quite similar in appearance, and positive identification is difficult in masticated samples. A checkup on the occurrence of these plants in southern Carter County showed snakeweed to be far the more common of the two; and it was identified positively in several of the samples.

Grass was fourth in volume of food taken, but second in occurrence. No sample contained much grass and several included only traces. The material was mostly of wheat grass (*Agropyron*), grama grass (*Bouteloua*), and some cheat grass (*Bromus tectorum*).

Weeds were identified mostly by their seeds and included thistle, knotweed, mallow, pigweed, ragweed, wild buckwheat, and dock.

Of interest was the use of cactus, found in 7 samples. The presence of seeds together with the fleshy, spined leaves leads to the belief that antelope seek the seed pods at this time of year rather than the entire plant.

Samples from other parts of the state and during other seasons of the year are needed to provide more general knowledge as to the food of Montana antelope.—FAYE M. COUEY, *Wildlife Restoration Division, State Fish and Game Department, Helena, Montana.*

REVIEWS

The Fox in New York. Clayton B. Seagers. Albany, N. Y., New York State Conservation Dept. Educational Bulletin (unnumbered). 85 pp. 37 figs. 1944.

Two recent popular bulletins[1] on the red fox are spicily styled with catchy wording, presumably in the hope of greater appeal to the general public. Only time and trial will prove whether such phrasing will teach sportsmen, farmers, and the lay public more of the fundamentals of wildlife biology than publications in conventional language.

The New York bulletin says: "The red fox is the best-loved and most hated, praised and berated, wisest, smelliest, daintiest, thinnest, sleekest, most flea-bitten and most controversial creature to occupy the ardent attentions of hound, hunter and hennery owner in the nation! He's a capital asset valued at more than $14,000,000 to New York in terms of his pelt. His by-products are nearly as numerous as the names called him by most sportsmen. There are many houndsmen who hunt him but won't shoot him. Small game hunters by the thousands believe there should be a bounty on his neck. Orchard owners, plagued by mice, want a bounty on those who want a bounty."

There are only 6 pages on life history but 12 on food habits, the latter by Robert W. Darrow, and including an appraisal of the significance of fox predation. Longer accounts deal with fox hunting in the American sense (not the British), and with trapping, skinning, and the subsequent handling of pelts. Besides photographs of fox habitat, tracks, and hunter catches, there are excellent ink drawings by Author Seagers. His "cartoons" on the ecology of the red fox under various stages of land use in New York and of methods in trapping and pelting convey the essential ideas tersely and clearly, and relieve the text of long descriptive accounts.—TRACY I. STORER.

[1] The second: Douglass, D. W., and G. W. Brandt. The fox—friend or foe? Lansing, Mich., Game Div., Michigan Department of Conservation. 23 pp. illus. 1945.

Education in Conservation of Soil and Water. Report of the Northern Great Plains Conservation Education Committee. Regional Division of Information and Education, Soil Conservation Service (U. S. Dept. of Agriculture), Lincoln, Nebraska. 47+6 pp., 1 pl. 1945. Free.

The Committee consists of eight professional educators, experts in curriculum building for elementary and secondary schools, from the six states of the region (Kansas, Nebraska, South Dakota, North Dakota, Montana, Wyoming). The report was prepared particularly for school administrators and teachers and written in educational terms. The document contains a clear concise analysis of the problem, together with appropriate, definite, and very usable suggestions for solution.

The first section states the imperative need for schools, both urban and rural, to give more adequate attention to education concerning protection, maintenance, rebuilding and proper utilization of soil and water resources which have suffered neglect to the point where there is deep concern and alarm among thinking people. The next section recommends that soil and water conservation find its place in the curriculum within present areas such as science, social studies, mathematics, English, and manual and fine arts at the elementary level, and in world geography, biology, American history, and problems of American democracy in grades 9 to 12, respectively. Sections III–VI contain recommendations for pre-service and in-service teacher training, resources for education which are expanded into a list in the appendix, and appropriate available materials with suggestions for selection and evaluation as well as development of additional needed materials. The last section lists suggested procedures that teachers, school administrators, education associations, and state and national agencies concerned with the problem may follow to implement the educational program.—GEORGE O. HENDRICKSON.

The Mosquitoes of the Southern United States East of Oklahoma and Texas. By Stanley J. Carpenter, Woodrow W. Middlekauff, and Roy W. Chamberlain. Notre Dame, Ind., University Press, 6+292 pp., 155 figs. 1946.

The stimulus that World War II gave to the study of mosquitoes is probably without parallel in the history of entomology. Among the many capable entomologists serving with the armed forces were the authors of this new text.

The early pages give a cursory discussion of the bionomics of mosquitoes and their role as vectors of disease, as well as techniques of collecting, mounting, and studying the various stages of these insects. The major portion of the book deals with the 71 species of mosquitoes found in recent years in the area indicated. The adult female and male and the larva of each species are described and excellently illustrated. It is a pleasurable convenience to find each illustration inserted with the corresponding descriptive material. All characters employed in the keys are well illustrated and indexed, together with the species, in the terminal seven pages. Even such rarely-encountered genera as *Wyeomyia* and *Deinocerites* are well figured. The distributional data are compiled from recent references and from collections by the Fourth Service Command Medical Laboratory. Selected references, totalling 188, follow the text. A field collector might desire more complete data on the seasonal abundance, biology, and particularly the ecological aspects of the mosquitoes discussed, but the taxonomist will find this book of the greatest help in making determinations. The authors attempted "to make the monograph a practical handbook for entomologists and public health workers" and have succeeded admirably.—STANLEY F. BAILEY.

Mammals of Nevada. By E. Raymond Hall. Berkeley, University of California Press. xi+710 pp., 11 pls., 485 figs. 1946. $7.50.

For few or no states has so comprehensive an account has been provided of the mammalian fauna as in this volume for Nevada. Stemming from an early and continuing interest by Miss Annie M. Alexander for studies in Nevada by the Museum of Vertebrate Zoology at Berkeley, it reports the results of a long and intensive program of field studies by Dr. Hall and many of his advanced students. To the original data so obtained have been added the results from previous studies by other persons and organizations. In all, 17,861 Nevada specimens were examined and the author spent 573 days on field work and travel in the state. The book is an account of the 233 species and subspecies accredited to Nevada, with brief accounts of life histories pieced out by information from elsewhere.

The introductory material (69 p.) deals with the physical and biological features of the state, the floral and faunal areas, factors responsible for geographic distribution and speciation of the mammals, a checklist, and a key faced by sketches of the principal generic types. The volume ends with a gazetteer of Nevada localities (22 p.), hypothetical list, list of Nevada type localities of mammals, illustrated glossary of mammalian terminology (14 p.), literature cited, and index (16 p.).

The colored frontispiece is of a typical Nevada scene, and the half-tone plates show representative environments in different parts of the state. Skulls of most species and subspecies are figured as line drawings. The ranges of species and subspecies within Nevada are shown on sizeable maps of the state, and smaller inset maps indicate the general range of the species in North America.

In the systematic accounts (pp. 109–642) Author Hall is appropriately inconsistent, dealing with families or genera according to the requirements of each for his purpose; for some there are extended discussions, and for others only brief remarks. Where a species is represented by two or more subspecies, the species is discussed first with such critical remarks as needed, and the ascertained facts as to natural history and ecology within Nevada are added. Then for each subspecies (or species where only one occurs), the final technical account includes distribution, remarks (including measurements and critical items as to coloration and skull), and a detailed list of records of occurrence

in Nevada based on specimens and the literature.

The work is in essence a taxonomic and distributional treatise, based upon scientific specimens obtained by trapping and shooting, with a fair amount of data from field notes as to habits, habitats, foods, etc. There are practically no quantitative data as to numbers taken on representative trap-lines per 100 trap-nights, or by other means. Hall guesses (p. 56) the average statewide population at 20 mammals per acre, (a figure identical with an earlier estimate by Grinnell for California), but gives only occasional remarks otherwise on populations. It would seem as though some other population data should have been obtained, since many workers participated through several years (pp. 5, 6).

A high degree of speciation among the mammals of arid Nevada is notable among the rodents, where some conspicuous examples are *Marmota* (1 species–4 subspecies), *Citellus* (8–13), *Eutamias* (9–13), *Perognathus* (4–11), *Microdipodops* (2–13), *Dipodomys* (5–14), *Thomomys* (4–29). In most instances the several species of a genus are ecologically segregated where two or more occur in a given locality, and the various subspecies of a species are sorted out geographically in different parts of the state. Examples of the two species of *Microdipodops* (*megacephelus* and *pallidus*), however, were taken close together in 12 localities; at one they were on unlike sandy soils but separated only by a gully 10 feet wide and 4 feet deep, and at another there was evidence in three specimens of hybridization between the two species.

Some useful ideas as to field methods include (p. 7) improved keeping of fresh specimens (up to 2 days) by taking measurements and weights, then eviscerating, and wrapping in waxed paper and in wet burlap; (p. 111) saturating ground with water around old mole runs to facilitate capture of specimens; and (p. 122) using for capture of *Sorex palustris*, in streams, Stirton's set of two floating boards on edge from the bank to make an open-based V with a trap set in the down-stream gap.

There are extended general accounts of the coyote (25 pp.), badger (12 pp.), and striped skunk (8 pp.), the latter with a first-hand experience with the bite and musk of *Mephitis* (in Kansas).

Dr. Hall gives (pp. 482–487) an excellent appraisal of the effects of beavers on both wild and cultivated areas. Also he has included several accounts by J. R. Alcorn, of Fallon, Nevada, based on many years of observation of the natural history of some species of economic importance, particularly for the badger, coyote (including methods of trapping), Townsend ground squirrel, and pocket gopher.

Dr. Hall has long been a critic of government programs to control predators in behalf of livestock and rodents in relation to crops and pastures, particularly in respect to the use of poison in such control. This book includes considerable discussion on these matters, in the main more tempered than some of his earlier writings. In summer badgers suffer from both traps and poison put out for coyotes, but fewer badgers are killed in winter campaigns since they then hole up extensively. Records showing fewer badgers than coyotes taken in summer during recent years, are held to show that the badger population of the state has been far reduced—aided also by private trapping for fur. Badgers reproduce more slowly than coyotes, hence do not recoup losses in population as quickly. Alcorn is quoted as believing that where badgers go unmolested, ground squirrels seldom attain to numbers requiring control.

The author discusses "coyote control" (pp. 249–263) as to its history in Nevada, methods used, why advocated, alleged gains and losses from different methods, facts bearing on control, his personal views on control, and a suggested plan for control in the state. The opposing viewpoints respecting control are fairly well stated, but the phrasing is quite general and no names of organizations or individuals appearing for the "prosecution" or "defense" are cited.

The historical account has a few figures as to gross costs and numbers of predators reported killed but no details by years or whether any proportionte change occurred as between trapping, poisoning, or other methods. Having introduced this controversial subject it would have been well to amplify the records and to cite data for years after 1934. The "facts" given are meager.

His proposals for coyote control are (1)

private trapping when fur is prime; (2) use of dogs to capture coyotes actually doing damage; (3) legislation to outlaw poisoned meat (suet) baits or cumulative poisons (*e.g.* thallium) on other baits; and (4) limiting federal assistance in control to advice and recommendations save in emergencies such as outbreaks of rabies. He introduces the idea of registered traplines on public lands (cf. Eklund, Jour. Wildl. Mgt. 10: 29–33, 1946) as part of his item 1 above. While this plan has great merit in conserving fur bearers, its use for coyote control in behalf of livestock (sheep) would seem to have decided limitations.

In respect to rodent control little is said. Dr. Hall agrees that wherever possible pocket gophers should be eliminated on cultivated lands (p. 443), but on wild lands efforts at control may be more harmful than beneficial (p. 445). He views large gopher populations on mountain meadows as one of several lines as evidence of overgrazing. In these opinions on rodent control the reviewer concurs, believing further that the extensive work at trapping and poisoning of gophers on mountain grazing lands during the heyday of the C.C.C. was mere boondoggling.

The "Mammals of Nevada" contains a wealth of material that will be of interest to students in a wide variety of fields for many years to come. It sets forth clearly the diversity of animal life present in the seemingly uniform expandes of a western "desert" state (as seen from a car window). Dr. Hall and his sponsors are to be congratulated on the production of a volume that is fine in many respects. To other states and to other workers in the same and allied fields the book is a challenge and an example to emulate.—TRACY I. STORER.

Bioenergetics and Growth with Special Reference to the Efficiency Complex in Domestic Animals. Samuel Brody. New York, Reinhold Publishing Co. xii+1023 pp. Many illus. 1945. [review copy received March 15, 1946] $8.50.

"This volume presents an integration of the researches sponsored by the Herman Frasch Foundation for Research in Agricultural Chemistry at the Missouri Agricultural Experiment Station." Indeed it is much more, being an extremely wide summation of data, both published and unpublished, obtained by the author and his associates, and by a great number of other investigators. Moreover it includes excellent broad summaries of knowledge in fields related to growth and metabolism. From his wide yet intensive reading, besides his intensive research interests, the author brings together material on many general and philosophical problems related to the welfare of mankind.

Early chapters establish basic ideas on energy metabolism as to growth and work, and discuss the effects of the plane of nutrition and the principle of diminishing increments on growth. A lengthy but detailed discussion follows on the role of vitamins, hormones, and minerals as metabolic agents and their service in the seasonal and daily rhythms of animals. Materials on both wild and domestic species and man are brought into close comparison.

Chapter 10 considers homeostasis, "the maintenance of a steady state," and the regulation for that purpose in various organ systems, bodily functions, and food components, closing with a brilliant discussion of "Social homeostasis" in populations—and problems in the evaluation and presentation of data. The role of temperature both external and internal then are considered, including the homeothermy of birds and mammals.

Succeeding chapters deal with methods in animal calorimetry, metabolism as related to weight, body surface-area, and pulmonary function. Others consider time and growth, linear growth, age and aging, physiological and time age, milk and egg production, and the efficiency of muscular work. The volume ends with a summary and integrating discussion of the materials considered.

The many tables contain great quantities of raw data on topics related to the general subject, particularly with reference to domestic animals and man. These and other numerical results also are presented in a great number of graphs relating to phenomena of growth and growth efficiency. So great is the quantity of material considered, however, that many of the graphs are complex and crowded, containing data on numerous individuals, species, or functions—and such graphs are quite difficult to read and interpret. The reviewer feels that it would have been more useful to select representa-

tive data and make the graphs less complex.

The sources of data throughout the volume are indicated by an abundance of footnote references to both published and unpublished sources.

Students of wildlife will not find a great deal of direct relation to their field of interest in this volume, but it contains much that they may read with profit as general background. Workers with wild species often envy investigators who deal with cultivated plants or domestic animals because the latter can exercise degrees of control over their experiments impossible for researches in nature. Wildlife workers may learn, however, much that is important from the studies on domestic animals reported in this volume.

It seems almost unnecessary to state that Professor Brody's book becomes at once a standard treatise for all who deal with growth and metabolism in animals.—TRACY I. STORER.

OBITUARY

RALPH M. KRIEBEL
1897–1946

Ralph M. Kriebel, a charter member of the Wildlife Society, was born at Hereford, Pennsylvania, October 12, 1897, and died at West Lafayette, Indiana, March 15, 1946. He graduated from Valparaiso University in 1921 and also attended Muhlenberg College and Columbia University. His main interests were in natural history, especially botany. In 1927 he gave up teaching because of ill health to become a stone carver in a Bedford, Indiana stone mill, and his handiwork for this period is found on many of the nation's structures. In 1924 he married Mary A. Roberts, who with a son, Robert, survive.

From 1926 to 1932 Kriebel collected plants as a hobby, and by sending specimens to Charles C. Deam for identification, his ability was brought to the attention of the U. S. Department of Agriculture, then searching for a botanist. Accordingly in 1935 he became associated with the Soil Conservation Service as biologist and farm planner, engaged in public relations work. In numerous youth camps he was instructor on conservation, nature study and astronomy, and served annually as a teacher at the Ohio "Conservation Laboratory" for teacher training. He served in a similar capacity in Tennessee. As a speaker on conservation and nature study he was much in demand. His popularity derived from his friendliness, sincerity of purpose, and contagious enthusiasm for his subject. Many people received encouragement and assistance from his ardent teaching and his championing of good things in nature and in men. In 1943 he became Assistant Extension Soil Conservationist for Purdue University, his joint employer with the U. S. Department of Agriculture from then until his demise.

As a taxonomic botanist, Kriebel will leave a lasting impression. His fine collection of nearly 11,000 specimens was begun in 1926, and was largely prepared on his own time. His thorough study of the flora of Lawrence County is unique in Indiana botany. Receiving neither income nor other compensation for expenses incurred, he was Indiana's topmost amateur botanist. Contemporaries unanimously named him an authority on the Genus *Quercus*. He excelled in ability to recognize small likenesses and differences. His knowledge of the grasses was outstanding. Other special interests were *Helianthus*, *Carex*, and the Pteridophytes.

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—C. M. KIRKPATRICK.

INDEX FOR VOLUME 10

Age determination
  cottontail, 171
  geese, 93
Aldous, C. M. Box trap for snowshoe hares and small rodents, 71
Aldous, Shaler E. Live trapping and tagging muskrats, 42
Aldous, Shaler E., see Harris, Dave, 348
Aldrich, John W. Significance of racial variation in birds to wildlife management, 86
Antelope, food, 367
Aquatic plants, 4

Bait
  colored, 353
  muskrat, 234
  peromyscus, 216
  poison mixtures, 177
  quail, 234
  rat, 162
  snare, 234
Baldwin, W. P., Jr. and C. O. Handley. Winter food of bobwhite quail in Virginia, 142
Banding
  bobwhite quail, 124
  muskrat, 42
Beaver
  management, 348
  trapping, 348
  use of oaks, 366
Bennitt, Rudolf. University objectives in professional wildlife training, 218
Birds
  effect of DDT on, 192, 195, 202, 208
  protection by colored baits, 353
  racial variation, 86
  reaction to humidity, 66
  research on islands, 239
Bishop, James S., and George P. Spinner. Quantities of weed seed produced in Connecticut cornfields, 300
Bonham, Kelshaw. Management of a small fish pond in Texas, 1
Brainerd, John W., see Stewart, Robert E., 195
Breeding
  white-tailed deer, 242, 249
Brown, Charles P. Food of Maine ruffed grouse by seasons and cover types, 17
Brown, C. P., see Martin, A. C., 8
Burroughs, R. D. Game refuges and public hunting grounds in Michigan, 285

Carrying capacity, bobwhite quail, 299
Census
  fish, 1
  pheasant, 277
Cheatum, E. L., and Glenn H. Morton. Breeding season of white-tailed deer in New York, 249
Cheatum, E. L., see Morton, Glenn H., 242
Coburn, Don R. and Ray Treichler. Experiments on toxicity of DDT to wildlife, 208
Conservation, megapod, 366
Control
  forest insect, 184
  gypsy moth, 202
  rodent 162, 353
Cook, David B. Summer browsing by deer on cut-over hardwood lands, 60
Cope, James B., see Stewart, Robert E., 195
Cottontails
  age tests, 171
  sarcocystis, 44
Couey, Faye M. Antelope foods in southeastern Montana, 367
Cover
  bobwhite quail, 111, 124
  "edge" in, 296
  multiflora rose, 227
  relation to grouse food, 17
  soil fertility, 77
Coyote
  food capacity, eggs, 33
  food habits, 33
  predation on quail, 111
  predation on waterfowl, 33
  scats, 275
Crabb, Wilfred D. and Leon Otis Emik. Evaluating rat baits by field acceptance trials on Guam, 162
Curtis, J. T. Use of mowing in management of white ladyslipper, 303

Davison, Verne E. False principles delay advancement in wildlife techniques, 296
DDT
  effects of, 181, 192, 195, 202, 208, 216
  birds, 195
  bird nests, 193
  fish, 183
  gypsy moth, 202
  mice, 216
  wildlife, 181, 208
Deer, black-tailed, 54
Deer, white-tailed
  breeding, 242, 249
  food, 47, 60
  in refuges, 285

Derris in fish ponds, 308
Disease
  cottontail, 44
Ducks
  effect of DDT on, 210

Editorial, 75
Eicher, George J., Jr. Lethal alkalinity for trout in waters of low salt content, 82
Einarsen, Arthur S. Management of black-tailed deer, 54
Eklund, Carl R. Effect of high explosive bombing on fish, 72
Eklund, Carl R. Fur resource management in British Columbia, 29
Elder, William H. Age and sex criteria and weights of Canada geese, 93
Enemies, of waterfowl, 33
Emik, Leon Otis, see Crabb, Wilfred D., 162
Erickson, Arnold B. Incidence and transmission of sarcocystis in cottontails, 44

Fire, effect on deer, 54
Fish, effect of bombing, 72
  DDT, 183
Fish detector, 175
Fish pond
  derris, 308
  management, 1
Fish, whitefish, 316
Food
  antelope, 367
  beaver, 366
  black-tailed deer, 54
  bobwhite quail, 137, 142, 296
  chemical composition, 12, 55
  coyote, 275
  game, 77
  gamebird, 8
  geese, 322
  pheasant, 300
  plants, 77
  rat, 162
  ruffed grouse, 12, 17
  turkey, 329, 333
  white-tailed deer, 47, 60
Fur, Canadian take, 29
  muskrat, primeness, 38

Gamebirds
  field studies, 239
  incubator for, 342
Game refuges
  Michigan, 285
Geese,
  Canada, 93
  age and sex criteria, 93
  estimating numbers, 365
  food of, 322
  weights, 93
Gensch, R. H., see Martin, A. C, 8
Glazener, W. C. Food habits of wild geese on the Gulf Coast of Texas, 322
Grit for bobwhite quail, 137
Grouse, ruffed
  food, 12, 17

Handley, C. O., see Baldwin, W. P., 142
Hare, snowshoe, trap, 71
Harris, Dave, and Shaler E. Aldous. Beaver management in the northern Black Hills of South Dakota, 348
Hasler, Arthur D. and Whitney, Lester V. A combination photoelectric light meter and fish-detector 175
Heit, William S. Unusual muskrat house, 276
Hendrickson, Geo. O., see Stiles, Bruce F., 277
Hill, Ralph R. Palatability ratings of Black Hills plants for white-tailed deer, 47
Hotchkiss, Neil, and Richard H. Pough. Effect on forest birds of DDT used for gypsy moth control in Pennsylvania, 202
Hunting
  cooperative, 274
  post-war, 72
  wild turkey, 329
Hunting grounds, public, 285

Incubator
  pheasant, 342
Index, Volume 10, 373

Jahoda, William J. Use of oaks by beavers in New Hampshire, 366

Kalmbach, E. R., and J. F. Welch. Colored rodent baits and their value in safeguarding birds, 353
Kellogg, Charles E. Variation in pattern of primeness of muskrat skins, 38

Ladyslipper, management, 303
Lane, Preston W., see Sylvester, W. R., 333
Lantern slides, filing, 63
Lehmann, Valgene W. Bobwhite quail reproduction in southwestern Texas, 111
Lehmann, Valgene W. Mobility of bobwhite quail in southwestern Texas, 124
Lewis, John H. Planting practice to reduce crop damage by jackrabbits, 277

Management
  beaver, 348
  black-tailed deer, 54
  fish ponds, 1, 308
  food for waterfowl, 4
  fur resource, 29
  ladyslipper, 303
  principles, 296

public hunting grounds, 285
refuges, 285
significance of bird races, 86
trapping, 29
water for waterfowl, 4
whitefish, 316
Martin, A. C., R. H. Gensch, and C. P. Brown. Alternative methods in upland gamebird food analysis, 8
Martin, Lenore, see Shelford, V. E., 66
Megapod, conservation, 366
Migration
bobwhite quail, 124
Miller, Richard B. Effectiveness of a whitefish hatchery, 316
Mitchell, R. T. Effects of DDT spray on eggs and nestlings of birds, 192
Mortensen, Otto A., see Thomsen, Hans Peter, 171
Morton, Glenn H. and E. L. Cheatum. Regional differences in breeding potential of white-tailed deer in New York, 242
Morton, G. H., see Cheatum, E. L., 249
Murie, Olaus J. Evaluating duplications in analyses of coyote scats, 275
Murie, Olaus J. The Merriam turkey on the San Carlos Indian Reservation, 329
Muskrat
breeding, 68
house, 276
live trapping, 42
parasites, 68
placental scar counts, 68
primeness in skins, 38
sex and age ratios, 68
size, 68
tagging, 42
weights, 68

Nelson, A. L., see Treichler, Ray, 12
Nestler, Ralph B. Mechanical value of grit for bobwhite quail, 137
Nestler, Ralph B. Potential value of islands for controlled studies on upland game birds, 239
Nests
destruction, 33
effect of DDT on, 193
quail, 111
waterfowl, 33
News notes, 74, 280, 360
Nicholson, A. J. Conservation of megapods by Solomon Island natives, 366
Nurseries, soil-fertility in, 77

Obituary
Kriebel, Ralph M., 370

Parasites
cottontail, 44
muskrat, 68
Palatability, deer food, 47
Peromyscus
effect of DDT on, 214, 215, 216
population, 150
trapping, 150
Petrides, George A. Snares and deadfalls, 234
Pheasant
census, 277
food, 300
incubator, 342
population, 241
Pillsbury, H. W., see Siegler, H. R., 308
Population
bird, 193, 197, 205
bobwhite quail, 111, 124
calculation by trapping, 150
cottontails, 171
Peromyscus, 150, 216
small mammal, 150
Pough, Richard H., see Hotchkiss, Neil, 202
Porcupine, copulation, 159
Predation, bobwhite quail, 111

Quail, bobwhite
effect of DDT on, 209
food, 137, 142, 296
grit, 137
movements, 124
nesting, 111

Rabbit, cottontail, 44
age in, 171
effect of DDT on, 213
Rabbit, jack
reducing damage by, 277
Rabbits, snowshoe hare, trap, 71
Rat control, 162
Rausch, Robert L. Parasites of Ohio muskrats, 70
Reactions to young birds to atmospheric humidity, 66
Refugees, game, 285
Reports, Wildlife Society
Ballot Committee, 273
Council Meeting, 269
Editor, 268
Finance Committee, 267
Financial Statement, 267
Minutes of the Annual Meeting, 270
President, 264
Secretary, 265
Treasurer, 266
Reproduction
bobwhite quail, 111
muskrats, 68
porcupine, 159
whitefish, 316

white-tailed deer, 242, 249
Reviews, 281, 368
Robbins, Chandler S., See Stewart, Robert E., 195
Rodent
  colored baits, 351
  poison baits, 177
Rose, multiflora hedges, 227

Sarcocystis, 44
Scott, Walter E. Possible increase in post-war hunting, 72
Shadle, Albert R. Copulation in the porcupine, 159
Shelford, V. E. and Lenore Martin. Reactions of young birds to atmospheric humidity, 66
Siegler, Hilvert R., and H. W. Pillsbury. Use of derris to reclaim ponds for game fish, 308
Sigler, William F. An experimental farmer-sportsman cooperative in Iowa, 274
Soil-fertility, 77
Sooter, Clarence A. Habits of coyotes in destroying nests and eggs of waterfowl, 33
Sooter, Clarence A. Muskrats of Tule Lake Refuge, California, 68
Spinner, George P. Improved method for estimating numbers of waterfowl, 365
Spinner, G. P., see Bishop, James S., 300
Steavenson, Hugh A. Multiflora rose for farm hedges, 227
Stewart, Robert E., James B. Cope, Chandler S. Robbins, and John W. Brainerd, Effects of DDT on birds at the Patuxent Research Refuge, 195
Stickel, Lucille F. Experimental analysis of methods for measuring small mammal populations, 150
Stickel, Lucille F. Field Studies of Peromyscus population in an area treated with DDT, 216
Stiles, Bruce F. and Geo. O. Hendrickson. Ten years of roadside pheasant censuses in Iowa, 277
Storer, Tracy I. Calculating poison bait mixtures, 177
Storer, Tracy I. DDT and wildlife, 171
Stow, R. W., see Treichler, Ray, 12
Streams, alkalinity in, 77
Sylvester, Walter R., and Preston W. Lane. Trapping wild turkeys on the Kentucky Woodlands Refuge, 333

Tagging
  muskrats, 42
Thomsen, Hans Peter, and Otto A. Mortensen. Bone growth as an age criterion in the cottontail rabbit, 171
Transplantation
  beaver, 348
  turkey, 333
Traps
  beaver, 348
  deadfalls, 234
  hare, 71
  Peromyscus, 216
  small rodents, 71
  snares, 234
Trapping
  fur, 29
  muskrat, 42
  Peromyscus, 150
  small live mammals, 150
  snares and deadfalls, 234
  snowshoe hare, 71
  turkey, 333
  wildlife, 234
Trapline, registered, 29
Treichler, Ray, see Coburn, Don R., 208
Treichler, Ray, R. W. Stow, and A. D. Nelson. Nutrient content of some winter foods of ruffed grouse, 12
Trout, lethal alkalinity for, 82
Turkey, wild, 329, 333
TVA impoundments, 4

University objectives in wildlife training, 218

Waterfowl
  coyote predation, 33
  estimating numbers, 365
  food, 4
  habitats, 4
  nesting, 33
Weed seeds as food, 300
Welch, J. F., see Kalmbach, E. R., 353
Weights
  Canada geese, 93
Whitefish, 316
Whitney, Lester V., see Hasler, Arthur D., 175
Wiebe, A. H. Improving conditions for migratory waterfowl on TVA impoundments, 4
Wilde, S. A. Soil-fertility standards for game food plants, 77
Wildlife and DDT, 181, 192, 195, 202, 208, 216
Wildlife Society
  Reports, 264
  Constitution and by-laws, 361
  Membership list, v–xxvii
Wildlife training, 218
Woods, Gordon T. Filing natural history slides, 63

Yeatter, R. E. Electric incubator for game-bird eggs, 342

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